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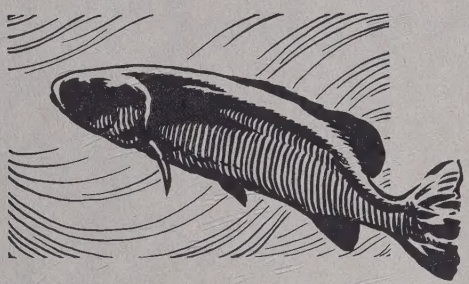

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UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

UNITED STATES DEPARTMENT OF THE INTERIOR
Fred A. Seaton, Secretary

FISH AND WILDLIFE SERVICE

THE PROGRESSIVE FISH-CULTURIST

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METHODS FOR DETERMINING THE EFFICIENCY OF PRODUCTION IN THE TROUT HATCHERY

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PUBLIC AGENCIES spend millions of dollars annually in the production of trout for the benefit of the country's sport fishermen. The published accounts for these dollars follow many patterns but usually are limited to receipts and expenditures on a fiscal-year basis. Seldom are costs correlated with the production of trout, and even more rarely do these reports include the operational details which permit an evaluation of the agency's trout production. Presentations of this nature are to be expected, as their primary purpose is a public accounting for funds entrusted to the agency. The inclusion of technical hatchery information would be useful to only a very limited number of readers and might confuse the primary issue. Occasionally, State conservation departments present more information in their official publications; often, however, these, too, offer only a limited amount of technical hatchery information.

The most complete report of accounting for both fiscal and fish-cultural matters is that published by Kingsbury (1951). Another very complete statement is that of Stephens (1953). The California Department of Fish and Game published in 1953 a fiscal breakdown of wages, fish food, and other costs for each of its hatcheries, including some technical information on fish culture. This same Department released similar information in 1955. From time to time other States have gone on record as to the "cost per pound" or "cost per thousand" of their hatchery trout production. The reader seldom knows what is included in the expenditures, the size of fish, or the relative efficiency of the hatchery operations.

As so few conservation agencies have published breakdowns of fiscal and fish-cultural techniques, there is some question as to whether the agencies are taking advantage of "yardsticks" which can be used to evaluate the efficiency of their individual hatchery units. Such evaluation is a necessity for economical production of hatchery trout. For the benefit of those who are not now making such analyses, the following criteria and comments are offered. To use certain of the criteria, additional information on both fiscal and fish-cultural problems probably will be required. The reduction of "red tape" is the goal of all administrators; but if this is carried too far, many dollars will be lost as a result of poor hatchery management. For example, some fishery workers consider hatchery feeding charts too time-consuming to be worthwhile; but Haskell found (1952) that the cost involved in maintaining these charts was less than 1 cent per pound of fish produced and indicated that they were a necessity for economical operations.

The Pound as a Unit of Measure

During the last 25 years, most conservation agencies have come to recognize the pound as the unit of measure in trout production. This unit is used in relation

to costs, food conversion, labor, and water utilization. Tables (Deuel, Haskell, Brockway, and Kingsbury, 1952; Tunison 1945) are available for use in converting pounds of trout to numbers of trout of different sizes. Knowledge of the size of trout is essential when certain criteria are used, as will be mentioned later.

The annual production of a trout hatchery should be stated in pounds. The period may be on a calendar- or fiscal-year basis, although the latter will give a more direct correlation with fiscal-year expenditures and save extra bookkeeping. The production should include actual inventories of fish, fish distributed, and deductions for fish and eggs transferred to the hatchery for further rearing. All weights should be actual, not estimated.

Size of Hatchery and Economy

Many agencies have learned that their larger hatcheries are the more economical. Overhead at a larger hatchery is usually less in relation to fish production, and a large fish production permits better utilization of labor. The cost of fish distribution may be somewhat higher, depending on the area served; but usually these costs are not a high percentage of the total.

Few criteria are suitable for direct comparison of a 100,000-pound hatchery and a 10,000-pound hatchery. Food conversion, production per gallon per minute of flow, and production per cubic foot of rearing space are about the only criteria that would have any real comparative significance. The cost per pound of production, production per man year of labor, and breakdown of fiscal percentages would have little significance other than to point out that the larger hatchery was the more efficient.

Production Potentials

Almost invariably hatcheries will be more economical if, regardless of their size, they are operated at full capacity. Kingsbury's (1950) is the best known method for estimating a trout hatchery's production potential. This is expressed in terms of pounds of trout produced (annual) per gallon-per-minute flow (average annual), and pounds of trout produced (annual) per cubic foot of rearing space used. In applying these factors, it is necessary to know certain things concerning the production requirement, water supply, rearing facilities, disease epidemics or other losses, and availability of operating funds.

In order to make full use of the water supply and rearing facilities, the hatchery should be in full operation the year round. If the management program requires catchable-size fish only, the production poundage often gained through distribution of fingerling fish in the fall months is lost. Fall stocking of fingerlings in lakes is considered to be a satisfactory practice where stocking is necessary, as in reclaimed lakes and farm ponds; and such stocking serves to improve the hatchery's efficiency and economy. Conversely, if only fingerlings are required for management (as is usually the situation in Pacific salmon hatcheries), then the production poundage of yearlings is lost during the winter months. Some States have a year-round trout fishing season, and in southern climates the use of spring-spawned and fall-spawned rainbow trout eggs permits a fuller use of the water supply and facilities. In other circumstances, capacity production at a hatchery may not be required for management purposes and this fact should be recognized in evaluating its production record.

Water supplies of poor quality have a detrimental effect on a hatchery's production. Low oxygen, high carbon dioxide or nitrogen, and various pollutants limit the use of water and may necessitate various corrective devices. Water temperatures are important. Temperature ranges of 45° to 60° F. for rearing purposes and 45° to 54° F. for hatching eggs are considered satisfactory. An average annual temperature of 50° to 54° F. is considered excellent, provided that maximum summer temperatures do not exceed 62° F. Average annual temperatures of 45° or less are usually detrimental to hatchery

efficiency and economy. Some hatcheries have corrected this, in part, by installing heating systems in the water supply or have arranged to transfer numbers of surplus fingerlings from hatcheries with more favorable water temperatures. Most hatcheries experience low water flows during the summer and fall. This condition limits the production of fingerlings and, if too severe, may affect the production of catchable-size trout. In the latter case, transfers of fingerlings from more fortunate hatcheries for winter holdover will help to make better use of the rearing facilities.

In evaluating a hatchery's production potential, it is necessary to know the type of rearing facilities available. Should a hatchery have only troughs for rearing purposes--and those troughs be either single or several in a series--the production per gallon per minute will be relatively low and the production per cubic foot will be as high as 4 or 5 pounds. If the rearing facilities are large ponds (or small lakes) which are oxygenated by the atmosphere as well as by the water supply, then the production per gallon per minute may be 40 pounds or more and the production per cubic foot will very likely be only 0.1 or 0.2 pound.

The water turnover in the rearing facilities should also be considered, as pointed out by Kingsbury (1951). The water changes per hour in troughs often number 10 or more, whereas the change in large ponds is usually in the low tenths or even hundredths. Eight-foot concrete raceways in new Federal hatcheries are designed for 2.5 water changes per hour in the first 100-foot section of a series. The length of a series usually is 300 feet, depending on a number of factors (including the quality of the water supply). The number of series of raceways is designed in relation to the total water supply. They are expected to produce from 1 to 1.5 pounds of trout per cubic foot.

If operating funds are limited, a hatchery cannot, of course, operate at capacity. A limitation of funds may be suspected if the production per gallon per minute and production per cubic foot are both low--assuming, of course, that the facilities and water supply are not in themselves limiting. Heavy losses of fish by disease epidemics or other causes, labor difficulties, and other factors that would have a direct detrimental influence on fish production should be known and recognized.

If the worker is familiar with the foregoing factors, then he has some license to use production per gallon per minute and production per cubic foot in evaluating a hatchery's potential and its current status.

Using the same criteria, it is possible to determine the best measures for expansion of existing facilities. With our present knowledge of fish culture, many hatcheries can have a production per gallon per minute of 30 to 40 pounds and a production per cubic foot of 1.0 to 2.0 where raceway-type ponds are used. Thus, if a hatchery has a production per gallon per minute of 10 pounds and a production per cubic foot of 4 pounds, additional raceways are indicated if full use of the water supply is to be made. Conversely, if the production per gallon per minute is 50 pounds and the production per cubic foot is 0.5 pound, it would be advisable to try to augment the water supply.

Data from 15 trout hatcheries are presented in the table. These particular hatcheries were selected to illustrate various criteria used in evaluating operational efficiency. In the light of the foregoing discussion on production potentials, additional rearing facilities are indicated for hatcheries 4, 5, 9, 13, and 15. Hatcheries 2, 3, and 8 have rather large dirt ponds in addition to raceways; and this accounts for the reasonably good utilization of the water supply, even though the production per cubic foot is low. Efforts are being made to augment the present water supplies at hatcheries 6 and 12.

Labor Efficiency

The efficiency of labor with respect to the production of trout and the over-all hatchery operations can be measured by the factor, production of trout (annual) per man year of labor. The labor should

TROUT PRODUCTION STATISTICS AT SELECTED HATCHERIES, 1955

Hatchery No.	Pounds of trout produced	Pounds of fish produced per Gallon per minute	Pounds of fish produced per Cubic foot	Average annual water temperature, °F.	Production per man year	Fish food Conversion	Fish food Cost per pound of fish produced
1	71,706	29.6	0.7	52	10,849	2.8	$0.26
2	70,187	25.0	.1	44	6,749	4.4	.34
3	54,918	32.3	.1	47	12,484	3.0	.29
4	37,031	10.2	1.0	46	7,980	4.4	.28
5	33,029	19.1	1.1	48	8,017	3.8	.26
6	25,123	46.5	1.2	51	6,281	3.0	.23
7	23,252	26.1	.5	50	5,497	4.3	.38
8	18,628	20.8	.2	44	4,622	2.9	.27
9	17,308	18.0	1.2	47	6,181	3.4	.26
10	16,141	11.6	.2	42	10,190	2.8	.27
11	15,223	13.3	.3	52	4,911	3.9	.37
12	15,163	47.9	.5	45	5,054	2.9	.24
13	13,314	9.8	1.7	50	6,724	3.1	.27
14	12,221	31.7	1.4	46	4,053	3.4	.27
15	8,136	16.3	4.7	52	2,937	3.0	.35
All hatcheries producing only trout	928,369	14.5	0.3	49	8,517	3.6	.30

Hatchery No.	Fish distribution Miles per trip	Fish distribution Pounds per trip	Fish distribution Cost per pound	Percentage of funds used for production	Percentage of total funds used for Labor	Fish food	Miscellaneous	Cost per pound of fish produced
1	100	483	$0.04	65	43	34	23	$0.78
2	---	---	----	57	42	27	31	1.27
3	37	352	.02	72	41	37	22	.78
4	112	504	.04	57	50	29	21	.97
5	172	410	.05	71	45	24	31	1.08
6	103	427	.03	60	49	18	33	1.24
7	293	411	.09	35	36	18	46	2.05
8	249	183	.25	51	52	18	30	1.55
9	64	227	.04	51	48	22	30	1.21
10	66	510	.03	59	50	36	14	.76
11	130	210	.09	36	28	12	60	3.01
12	139	179	.06	76	72	20	8	1.19
13	---	---	----	77	55	32	13	.84
14	49	133	.05	55	59	19	22	1.40
15	400	121	.34	61	54	14	32	2.38
All hatcheries producing only trout	122	420	.04	59	44	29	27	1.03

include both permanent and temporary positions converted to man years on the basis of a 40-hour week, or such other period as an agency may desire. Size of hatchery and local operations have considerable influence on this factor. Large hatcheries usually have the highest production per man year. Exceptions are sometimes found at rearing units that are dependent on other sources for their supply of fingerling fish and sometimes for fish food and fish distribution; i.e., hatchery 10 in the table. Large hatcheries have smaller overhead in relation to their fish production, and those producing 50,000 pounds or more annually should expect a production per man year of at least 10,000 pounds if no unusual operating conditions exist.

Hatcheries whose water supplies limit the production of fish to less than 10,000 pounds can seldom expect to get a production per man year of 10,000 pounds. A minimum of two men is required at most

hatcheries for safety precautions, fire prevention, protection of property, and custodial duties. Often these men work much harder and under more difficult conditions than men at large hatcheries; yet their productive efforts, as reflected in the production per man year, give little indication of this.

Limitation of funds or fish food, as well as rearing facilities, can be detrimental to the production per man year. Also to be considered are the age, number, and ability of employees; extremely heavy fish-distribution work; and extra-curricular work such as park maintenance, fish salvage, public relations, and stream, pond, and lake surveys. Haskell's time study (1952) showed that labor was used in his hatchery for a variety of operations, and the study inspired several suggestions as to ways to economize on labor.

As the work week is not the same for all agencies, there may be some merit in using production per man hour instead of production per man year of labor. Regardless of the unit employed, it would be helpful to the reader if the length of the work week were mentioned in reports dealing with this factor. In the Federal Government, the work week is 40 hours; production per man year is divided by 2,080 to determine production per man hour.

Production per man year is a good criterion for use in evaluating a hatchery's efficiency, but its limitations should be recognized.

Fish Food Efficiency

For many years the conversion of fish food into trout flesh and the food cost of production have been recognized as major criteria in measuring the efficiency of a hatchery's operation. They have been very important to the man operating the hatchery, because very often he is unfamiliar with other hatchery expenses--which are handled by the agency's main office. Feed conversions are important in evaluating the quality of a feed and, under certain conditions, may also assist in evaluating quantity feeding. The food cost of production is important to the administrator as well as to the hatcheryman. It is particularly important now that dry pellets are being used in many hatcheries. The proper use of present-day pellets will lower the feed conversion and will lower the hatchery's labor cost; it may also lower the food cost.

Feed conversion and the food cost of production on an annual basis may be determined by very simple arithmetic. Unfortunately, poor results cannot be corrected. Feeding charts designed to control feeding efficiency have been in use in many hatcheries for a number of years. The charts and methods of operation were described by Deuel, Haskell, Brockway, and Kingsbury (1952).

The efficiency of a hatchery's operation should be questioned when the feed conversion exceeds 3.5 or the food cost of production is greater than 35 cents per pound, current prices prevailing.

Factors Concerned With Fish Distribution

It is difficult to analyze the cost of distributing fish because the problems involved in this work vary with the hatchery's location and the agency's stocking practices. The cost of labor and truck operation often amounts to 2 to 3 percent of the total cost of the hatchery's operation and sometimes is as high as 5 percent. The cost per pound of fish distributed can be used to measure a hatchery's efficiency if one is familiar with the difficulties of the distribution work and judges accordingly. Two factors that have primary relation to the costs and should be given equal or even greater recognition are the miles traveled per trip (round trip) and the pounds hauled per trip. Long trips and small loads result in high cost of distribution. Distribution tanks equipped with units for water circulation, compressed air, or oxygen cylinders have been developed to haul 1,000 pounds or more of catchable-size trout for distances of several hundred miles. The use of anesthetics such as tricaine methanesulfonate (M. S. 222) may permit

even larger loads. A sufficient number of efficient distribution units is essential at distribution time to prevent a bottleneck at the hatchery. A day's gain in weight of trout at large hatcheries may equal the weight of a distribution load; and unless the fish are moved, they may become so crowded that excessive losses occur.

Utilization of Funds

A breakdown of a hatchery's expenditures is essential if its efficiency and economy of operation are to be analyzed. How much money was spent to raise fish? and how much was used to cover other requirements at the hatchery? Some people feel that if a hatchery is allotted $20,000, the whole of this amount plus interest on the investment in the hatchery should be charged against fish production. Other people question the propriety of charging expenditures for such items as new construction, "park" maintenance, experimental work, hatchery assistance given other activities in the agency, central-office overhead, and amortization of the facilities. Because of the differences in the organizational structures and policies of the various conservation agencies, agreement on all these items cannot be expected. In view of this, a direct comparison of the cost of producing trout in two or more agencies may have little meaning. Such a comparison will gain in significance, however, if it is known what costs are included.

Expenditures for certain activities or items are often shown as a percentage of the whole on an annual basis. Unusual expenditures for one activity during a year may cloud the percentage picture. A 3- or 5-year average may be more representative. Discretion should be used in evaluating percentage breakdowns, as low value for one item will result in higher values for others, the total being 100 percent.

Hatchery operations usually consist of the rearing and distribution of fish, maintenance of facilities, and general operations which do not directly involve either of these. Federal hatcheries have maintained a cost-accounting procedure for their funds and labor for 10 years, and it has been possible to arrive at certain conclusions regarding their expenditures. The funds included were those allotted to the hatcheries and used to rear and distribute fish, to maintain and make minor improvements to facilities, and for general operations. Excluded were funds received by specific appropriations for construction, regional and central-office overhead, and interest on the investment. Instructions were issued to serve as guidelines for the assignment of expenditures of funds and labor. Briefly, labor and funds used specifically for rearing and distributing fish were charged to fish production; those used specifically for maintenance and repair of facilities were charged to maintenance; and labor and funds used for such items as janitorial duties, transfer of personnel, and office supplies were charged to operations. It has been found that, on the average, 60 percent of the trout hatchery's funds and labor expenditures are used for fish production, 30 percent for maintenance and repairs, and 10 percent for operations not directly concerned with either fish production or maintenance. It has been learned also that the larger hatcheries used a higher proportion of their funds and labor (often amounting to more than 70 percent) for fish production. Small hatcheries usually were high on maintenance and operations. The percentage production cost for the trout hatcheries listed may be seen in the table. Heavy expenditures for maintenance resulted in a smaller percentage of expenditures for fish production in hatcheries 2, 7, and 11. Minor maintenance required for normal operation of hatcheries 13 and 15 usually resulted in rather high percentage values for fish production for those hatcheries. Breakdowns of expenditures such as these serve to control exorbitant use of funds for fish production or maintenance, as the case may be, and to permit more orderly execution of the hatchery's program.

Another type of fiscal breakdown is that used by Kingsbury (1951), Stephens (1953), and the California Department of Fish and Game (1955). This type gives

the relative expenditures for salaries (or labor), fish food, and miscellaneous items, expressed either in percentage of total costs or in terms of the respective costs per pound of fish produced. The usual records provide the information for labor and fish-food expenditures, and the difference between the sum of these and the total costs represents the miscellaneous costs. Under this type of breakdown, a ratio of 45 for labor, 35 for fish food, and 20 for miscellaneous would probably not be unusual. Higher values for labor would result when the fish production per man year of labor expended was low. High maintenance costs would be reflected in a high miscellaneous cost. Percentage-wise, fish food would be highest only at the larger hatcheries and might equal or exceed labor costs. Except for years of heavy maintenance or repairs, the larger hatcheries would have the lowest miscellaneous costs. This type of breakdown, like the one mentioned before it, can serve as a control on hatchery expenditures, although both are limited in their use unless supplemental information is available.

Cost Per Pound of Trout Produced

Of all the criteria mentioned, the cost per pound of fish produced is considered to be the most significant single figure that can be used to judge a hatchery's efficiency. This figure reflects the composite of facilities, operations, and efficiency in relation to fish production. By itself, however, the cost per pound of fish produced has very limited value in analyzing a hatchery's operations for the purpose of making improvements. A hatchery producing at a cost of $2 a pound may be more efficient for the circumstances in which it operates than a hatchery with a cost of $1 a pound. Costs of production can often be reduced, but information on the criteria mentioned previously must be available before much progress can be made. The cost of producing a pound of trout has value in calculating potential production with anticipated or available funds; but a hatchery's operating peculiarities must be recognized in making the estimate.

Summary

An evaluation of a hatchery's efficiency and its economy of operation is contingent on knowledge of a number of fish-cultural and fiscal criteria. No one of these criteria is very significant by itself, but all must be given consideration to assure--when conditions permit--constructive improvements in the hatchery's management.

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SOME NEW RESULTS IN THE TREATMENT OF PONDS TO CONTROL SOME EXTERNAL PARASITES OF FISH

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TO CONTROL EXTERNAL PARASITES OF FISH, FISHERY WORKERS in the past have experimented with a large number of chemicals and methods of application. Although these experiments have met with varying degrees of success, very little quantitative work has been reported.

Tests in aquaria and ponds have been conducted to determine the efficacy of formalin and potassium permanganate in concentrations that could be tolerated by fish populations over long periods of exposure. Most of the previous work on this type of chemical control has been restricted to dips of short duration or to short exposures under circumstances in which a raceway or pond could be flushed to reduce the concentration after a prescribed period of exposure. No work has been reported on treatments wherein a body of water is treated with a given concentration of a chemical and the fish are exposed to this material until its natural dissipation occurs. Obviously, only very low concentrations of most chemicals could be used under such circumstances.

MATERIALS AND METHODS

Parasitized fish were obtained from several local impoundments, including the ponds of the Agricultural Experiment Station of the Alabama Polytechnic Institute. Parasitized populations were usually discovered because of unusual mortality reported by Station personnel or local pond owners. In most of these instances, the epizootics were caused by a single parasitic species and rather uniform infestations suitable for experimentation could be obtained.

Parasitized fish were brought into the laboratory and stocked at the rate of 10 fish to each 40-liter aquarium. Three concentrations of formalin and three of potassium permanganate were tested. The formalin was used in concentrations of 5, 10, and 15 p.p.m. Potassium permanganate was used in concentrations of 2, 3, and 4 p.p.m. In each test, fish in untreated aquaria were maintained as controls.

The test fish were usually exposed to the treatment for 72 hours. At the end of the test period, the fish were removed and counts were made of the parasites on each group of fish.

Embody's technique (1942) was used in removing gyrodactylid trematodes. The test fish from each treatment were placed in 500-milliliter beakers containing a 1 to 4,000 solution of cresol. The fish were removed after a 10-minute exposure. The parasites in the solution were first concentrated by pouring the solution through the detachable bucket of a Wisconsin-type plankton net (Welch 1948: 240, fig. 66) equipped with bolting cloth that had a mesh of 48 by 64 microns. After the sides of the net were carefully washed down, the fluid was drained into a 6.5-milliliter McNaught centrifuge tube. The fluid was then centrifuged for 20 minutes at slow speeds. The parasites were concentrated

in the narrow end of the tube. They were removed from the tube with a thin pipette and transferred to a modified Sedgwick-Rafter counting cell. The counting cell used was made by sealing a 50- by 20- by 1-millimeter brass rectangle to an ordinary 1- by 3-inch glass slide. This cell had the capacity of exactly 1 milliliter. As total counts of all parasites in the cell were to be made, a grid within the bounds of the rectangle was scratched on the slide to facilitate counting. The total number of parasites removed from each group of test fish was counted and recorded.

This technique, with minor modifications, was used on other parasitic species tested. It was found that the cresol solution would not remove Trichodina from the host fish. For this parasite, 10 percent formalin was used. In experiments with Ichthyophthirius, no method was found that would remove all of the parasites for quantitative studies. For this parasite, the efficacy of the compounds tested was measured by gross observation of the parasitized animals. Tricaine methanesulfonate (M.S. 222) was used to narcotize the fish temporarily to facilitate observation with a stereoscopic microscope.

After the aquarium tests were completed, the impoundments from which the parasitized fish were taken were treated. First, the volume in acre-feet of water was determined by multiplying the average depth in feet by the number of acres in the pond. As 1 acre-foot of water weighs 2.7 million pounds, 2.7 pounds of chemical per acre-foot would be necessary for a concentration of 1 p.p.m. In this manner, the number of pounds necessary for the desired p.p.m. was calculated. Formalin was applied to the pond from a container having a "gravity flow" hose line into the water. The hose line was held over the side of the boat, in the propeller wash, as the boat was driven back and forth over the surface of the pond. Each volume of formalin in the container was diluted with five volumes of water prior to being applied to the pond. Potassium permanganate was applied from a coarsely woven bag held over the side of a boat. After the application of these materials, a boat powered by a 5-horsepower outboard motor was driven back and forth across the pond several times in an effort to agitate the entire surface.

RESULTS AND DISCUSSION

Gyrodactylus

In June 1955, a large number of fingerling speckled bullhead (Ameiurus nebulosus marmoratus) taken from a pond in central Alabama were examined for parasites. These fish were heavily infested with Gyrodactylus. In an effort to control this parasite, experiments with formalin and potassium permanganate were set up in 40-liter aquaria as previously described.

Formalin.--The results in the aquarium tests with formalin are presented in table 1. In the experiment where 3 concentrations of formalin were tested in 5 replications, all concentrations from 5 to 15 p.p.m. averaged between 92 and 99 percent reduction of infestation as compared with the untreated controls. Only 2 replications of the tests with 5 p.p.m. gave less than 90 percent control, and all replications with 10 p.p.m. and 15 p.p.m. gave better than 99 percent control.

After the aquarium tests were completed, the 2-acre pond from which the parasitized fish were taken was treated with 5.5 p.p.m. formalin as previously described. At the end of the first 72-hour period after treatment, a sample of 40 fish was removed and the parasites were counted (table 2). In this instance, the average control obtained was 93.4 percent, as compared to 92.3 percent in the aquarium tests. Four weeks after treatment, a second sample of 40 fish was removed from the pond and found to be completely free of Gyrodactylus. The data from the pond treatment suggest that had the fish in the aquarium tests been held longer, complete control might have been obtained with 5 p.p.m. formalin.

Potassium permanganate.--The results of the aquarium tests with potassium permanganate are shown in table 3. In a

TABLE 1.--The effect of formalin on Gyrodactylus on speckled bullhead fingerlings in aquaria

/Ten fish per replication/

Treatment	Replications										Average	
	1		2		3		4		5		Replication (number)	Control (percent)
	(N)	(P)	(N)	(P)	(N)	(P)	(N)	(P)	(N)	(P)		
Untreated control	2,529	-----	1,179	------	888	------	1,087	-----	1,176	------	1,371.8	-------
5 p.p.m. formalin	170	93.30	30	97.46	72	99.19	114	89.52	138	88.29	104.8	92.37
10 p.p.m. formalin	25	99.02	1	99.92	11	99.88	1	99.92	8	99.32	9.2	99.33
15 p.p.m. formalin	2	99.92	0	100.00	0	100.00	5	99.89	0	100.00	1.4	99.99

(N) -- Number of parasites. (P) -- Percentage of control.

TABLE 2.--The effect of formalin on Gyrodactylus on speckled bullhead fingerlings in a pond

/Ten fish per replication/

Period	Replications								Average	
	1		2		3		4		Replication (number)	Control (percent)
	(N)	(P)	(N)	(P)	(N)	(P)	(N)	(P)		
Prior to treatment------	1,179	------	888	------	1,087	------	1,176	------	1,075	-------
72 hours after treatment	22	98.14	69	92.23	99	91.90	94	92.01	71	93.45
4 weeks after treatment	0	100.00	0	100.00	0	100.00	0	100.00	0	100.00

(N) -- Number of parasites. (P) -- Percentage of control.

single unreplicated experiment, concentrations of 2, 3, and 4 p.p.m. each gave better than 95 percent control. The treatments with 2, 3, and 4 p.p.m. potassium permanganate were slightly more efficient than the treatments with 5, 10, and 15 p.p.m. formalin, respectively. The potassium permanganate was not used in field tests because no more ponds containing fish infested with this parasite were available.

Trichodina

In March 1956, speckled bullheads taken as a sample from one of the Agricultural Experiment Station ponds were examined and found to be heavily parasitized with Trichodina. Aquarium tests with formalin and potassium permanganate were conducted.

Formalin.--The data from the formalin tests (table 4) indicate that Trichodina was more difficult to control with formalin than Gyrodactylus. Treatments with 5 and 10 p.p.m. formalin were unsatisfactory, giving an average of 55 and 82 percent control. A concentration of 15 p.p.m. was necessary to obtain a satisfactory control of 99 percent.

Potassium permanganate.--The data from the tests with potassium permanganate in aquaria are presented in table 5. They indicate that this compound, when used at a concentration of 4 p.p.m., was superior to 10 p.p.m. formalin and was approximately equal to 15 p.p.m. formalin for controlling Trichodina.

After the tests in aquaria, the pond from which these parasitized fish were obtained was treated with 3 p.p.m. potassium permanganate as previously described. Seventy-two hours after this treatment, a sample of 40 fish was taken from the pond and the parasites were counted (table 6). In this instance, the average percentage of control was 89.4, as compared with 90.9 percent control in the aquaria tests. Four weeks after treatment, a second sample of 40 fish was removed from the pond and found to be completely free of Trichodina.

TABLE 3.--The effect of potassium permanganate on Gyrodactylus on speckled bullhead fingerlings in aquaria

[Ten fish per treatment]

Treatment	Total parasites (number)	Control (percent)
Untreated control	2,773	-------
2 p.p.m. potassium permanganate----	104	96.25
3 p.p.m. potassium permanganate----	8	99.72
4 p.p.m. potassium permanganate----	3	99.90

Ichthyophthirius multifiliis

Specimens of this parasite were obtained from bigmouth buffalo (Ictiobus bubalus) fingerlings that had been taken from one of the Agricultural Experiment Station ponds. A population of bluegill sunfish (Lepomis macrochirus) was exposed to this parasite in order to obtain a uniform parasitic population for experimental work. After a heavy infestation had been obtained, each of five 40-liter aquaria was stocked with 10 fish taken at random from the parasitized population. Concentrations of 5, 10, and 15 p.p.m. formalin were used in an effort to control this parasite. One aquarium was maintained as a control.

Within 48 hours, 100 percent mortality of the host fish occurred in the control and in the 5 p.p.m. treatment. In the 10 and 15 p.p.m. treatments, mortalities of 80 and 50 percent, respectively, occurred. Two fish from the group that received the 10 p.p.m. treatment and five fish from the group that received the 15 p.p.m. treatment recovered and did not become reinfested within the 2-week period of observation.

The aquaria tests seem to indicate that Ichthyophthirius multifiliis may be controlled by means of a single application of 15 p.p.m. formalin if the parasitized fish are treated before they have become badly weakened by the parasite.

TABLE 4.--The effect of formalin on Trichodina on speckled bullhead fingerlings in aquaria

/Ten fish per replication/

Treatment	Replications								Average	
	1		2		3		4		Replication (number)	Control (percent)
	(N)	(P)	(N)	(P)	(N)	(P)	(N)	(P)		
Untreated controls	2,357	------	1,915	------	1,545	-----	4,423	-----	2,560	-----
5 p.p.m. formalin	1,025	56.52	925	51.70	452	70.75	2,158	51.21	1,140	55.47
10 p.p.m. formalin	237	90.00	406	88.80	142	90.81	1,040	76.49	451	82.18
15 p.p.m. formalin	0	100.00	0	100.00	112	92.76	32	99.28	36	98.60

(N) -- Number of parasites. (P) -- Percentage of control.

TABLE 5.--The effect of potassium permanganate on Trichodina on speckled bullhead fingerlings in aquaria

/Ten fish per replication/

Treatment	Replications								Average	
	1		2		3		4		Replication (number)	Control (percent)
	(N)	(P)	(N)	(P)	(N)	(P)	(N)	(P)		
Untreated controls----------	1,140	------	1,430	-----	1,080	-----	1,205	-----	1,213	-----
2 p.p.m. potassium permanganate	225	80.27	400	62.05	175	83.80	305	74.69	276	77.24
3 p.p.m. potassium permanganate	150	86.85	93	93.50	108	90.00	87	92.79	109	90.98
4 p.p.m. potassium permanganate	0	100.00	5	99.76	12	98.89	9	99.26	6	99.47

(N) -- Number of parasites. (P) -- Percentage of control.

TABLE 6.--The effect of 3 p.p.m. potassium permanganate on Trichodina on speckled bullhead fingerlings in a pond

/Ten fish per replication/

Period	Replications								Average	
	1		2		3		4		Replication (number)	Control (percent)
	(N)	(P)	(N)	(P)	(N)	(P)	(N)	(P)		
Prior to treatment------	1,140	------	1,430	------	1,082	------	1,205	------	1,213	-------
72 hours after treatment	185	83.78	105	92.66	130	87.99	92	92.37	128	89.46
4 weeks after treatment	0	100.00	0	100.00	0	100.00	0	100.00	0	100.00

(N) -- Number of parasites. (P) -- Percentage of control.

No tests of this have yet been conducted in ponds.

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EXCERPT: A SIX-YEAR STUDY OF THE SURVIVAL AND VITALITY OF HATCHERY-REARED RAINBOW TROUT OF CATCHABLE SIZE IN CONVICT CREEK, CALIFORNIA

It is evident from these experiments that rainbow trout hatched and reared to catchable size at Hot Creek Hatchery, of both fall-spawning and spring-spawning stock, exhibited an ability to survive equal to that of resident wild brown trout of comparable size. It is also clear that the hatchery trout were capable of competing with wild brown trout of the same size, even though the hatchery fish were compelled to make rather drastic adaptations to the wild and entirely foreign environment. There was no evidence to indicate that the survival of the hatchery trout was influenced by the absence of the processes of natural selection during early life stages in the hatchery. If the hatchery trout possessed abnormal physical condition due to fish-cultural techniques, and to stocking practices and methods, their abnormalities evidently were not critical factors in their ability to survive.

If it is true that hatchery trout are generally inferior to wild trout, then it is only reasonable to infer that the rainbow trout produced at Hot Creek Hatchery are demonstrably superior in quality and that the reason or reasons for this superiority must be found in the hatchery and its operational procedures. ...

It was demonstrated ... that mortality in small streams is indeed high among wild trout, as well as among hatchery-reared trout. However, were the observed losses "high" or were they normal for the test periods in consideration of the species and origins of trout utilized? ... the experimental evidence indicates that time is the grim reaper--that mortality progresses with time and that the mortalities experienced in the trials are probably within the yearly expectation of natural death. It is therefore of paramount importance that hatchery-reared trout of catchable size be stocked immediately prior to and during the open season in areas of heavy angling pressure in order to realize greatest benefits. This is in confirmation of generally accepted practice, but the concept that hatchery trout so stocked would not be available to anglers a few weeks after stocking is untenable. Equally untenable are the concepts that overwinter survival of hatchery-reared trout is always poor, and that these trout suffer heavy mortality immediately after planting or during short periods following planting. Actually, fall-stocked trout exhibited higher survival levels than those stocked in the spring, considering equal periods of residence in the stream. However, in winters where conditions are extreme and protracted, mortality is exceptionally high and more drastic among hatchery-reared trout than among wild trout.

-- Conclusions, "A Six-Year Study of the Survival and Vitality of Hatchery-Reared Rainbow Trout of Catchable Size in Convict Creek, California" by R. S. Nielson, Norman Reimers, and H. D. Kennedy. California Fish and Game 43 (1): 5-42. January 1957.

ACUTE SULFAMETHAZINE TOXICITY IN YOUNG SALMON

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ADVERSE EFFECTS FROM THE MEDICATION OF FISH DISEASES WITH SULFONAMIDES have been reported by several workers. A decreased growth rate (Gutsell and Snieszko 1949, Snieszko and Wood 1955), the production of drug-resistant strains of pathogens (Snieszko 1952), sterility and kidney damage (Wood et al., 1955), and mortalities (Johnson and Brice 1953) have been described.

Recently, increased mortalities and tissue damage were observed in young silver salmon after a single day's treatment with sulfamethazine. Subsequently an attempt to reproduce the conditions experimentally was made. The purpose of this paper is to describe the pathology of acute sulfamethazine toxicity and to discuss certain factors of possible importance in the etiology of losses among fish treated with sulfonamides.

Materials and Experimental Work

A septicemic pseudomonad infection occurred in young fall chinook salmon at the Fish and Wildlife Service's hatchery at Spring Creek, Washington, in the spring of 1956. An infected lot was divided into two groups, with 950 pounds of fish in each group. Sulfamethazine was fed to one group; sulfamerazine, to the other. Dosage was at the rate of 10 grams of sulfonamide per 100 pounds of fish per day. Water temperature was 46° F.

After one day of medication, the losses in the group receiving sulfamethazine were three times greater than the losses in the group receiving sulfamerazine and treatments to the former group were stopped. Losses continued high for 4 days. Moribund fish characteristically had extremely swollen stomachs and a marked constriction just anterior to the gastric caeca. Sulfonamide crystals were observed in histological sections of the kidneys, and the drug was considered as the presumptive cause of the mortality.

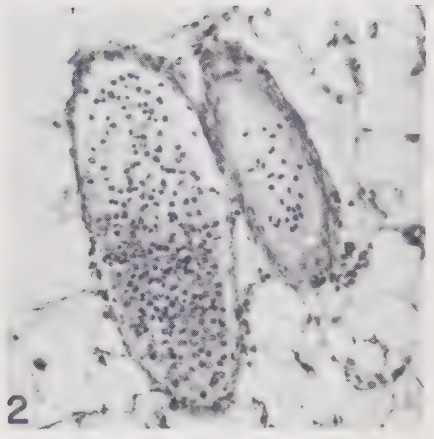
Subsequently, 10 pounds of uninfected fish were placed in an experimental tank at the Spring Creek station and were given sulfamethazine therapy at the rate of 10 grams of drug per 100 pounds of fish per day for 3 days. No mortalities occurred. Next, 10 pounds of the pseudomonad-infected fish were given the experimental therapy for a 3-day period. The results were again negative. This suggested that possibly an overdosage had occurred during the preparation of the production diets. Accordingly, small groups of uninfected fish were acclimated in experimental tanks at the Salmon Nutrition Laboratory until they were feeding avidly. They were then offered diets containing 10, 30, 100, 150, 300, 500, 700, and 1,000 grams of sulfamethazine per 100 pounds of fish per day for periods as long as 5 days. Dosage at rates as high as 150 grams was apparently tolerated by the fish for this entire

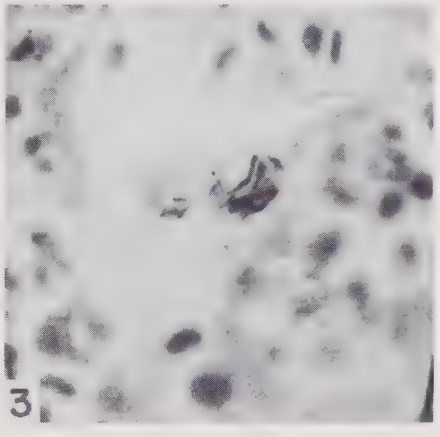
FIGURE

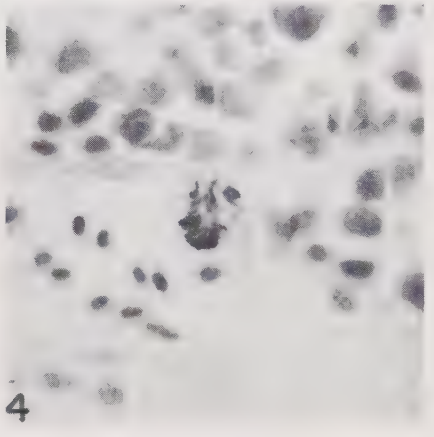
1.--Gross appearance of acute sulfamethazine toxicity. Note the swollen stomach and constricted zone anterior to caeca.

2.--Necrosis of arterial walls in mesenteric vessels. x 200.

3, 4.--Sulfamethazine crystals in kidney tissue. x 900.







period without adverse effects. At dosage rates of 300 grams and above, the fish usually refused feed after 24 hours of medication, developed markedly swollen stomachs and a constricted zone anterior to the gastric caeca, and suffered a low mortality (less than 1 percent). Kidney sections from these fish, however, did not contain sulfamethazine crystals.

A variety of physiological conditions is known to contribute to the occurrence of sulfonamide precipitation in the kidneys. Such factors as dehydration and pH level are especially important. Accordingly, a number of experiments were set up in an attempt to produce sulfamethazine crystals in fish kidneys. Avidly feeding, uninfected fish were fed diets containing sulfamethazine at the rate of 700 grams per 100 pounds of fish per day. In an attempt to upset the osmotic balance, one group was fed 5 percent sodium chloride. After 24 hours of medication, all fish refused feed. One group was then placed in a distilled-water aquarium, and another group was placed in an aquarium containing 0.5 percent sodium chloride. Two additional groups were placed in aquaria where the pH had been raised to 8.0 with sodium hydroxide and lowered to 4.0 with hydrochloric acid. The control aquarium contained spring water at a pH of approximately 7.0 with no salt added. Further experimental details are not provided because all the experiments were negative; i.e., sulfamethazine precipitation was not achieved under any conditions.

Pathology

Extensive pathology was not observed in any of the material studied, either from the experimental groups or from the original mortality at the Spring Creek station. The tissue damage was apparently confined primarily to the vascular system and consisted of degenerative lesions in small arteries, particularly in the visceral area. This resulted in extensive

edema throughout the abdominal cavity, but most markedly in the pancreatic and adipose tissues surrounding the gastric caeca. Minor degenerative lesions were observed in the renal tubules and in the parenchymal cells of the liver. These lesions were more extensive in the original Spring Creek material than in any subsequent experimental fish.

Of particular interest were small crystalline structures observed in the hemapoietic tissue of the kidney. These appeared as brown or dark-yellow refractile crystals in hematoxylin and eosin sections. Glick (1949) described a test devised by MacKee and coworkers (1943) for the detection of sulfonamides in frozen tissues. A slight modification of this method was found to be suitable for the crystals in these paraffin sections. To describe this method briefly, 1 gram of p-dimethylaminobenzaldehyde was dissolved in 95 milliliters of absolute alcohol and 5 milliliters of concentrated hydrochloric acid. This solution was introduced under the cover slip of a hydrated section while a crystal was being observed under the microscope. The reaction was immediate. The crystal turned lemon yellow or bright orange and dissolved. The entire reaction occurred in approximately 1 minute. Pure sulfamethazine crystals reacted in an identical manner, and the test was considered as sufficiently specific for positive identification of the crystals.

Discussion and Summary

It is apparent that there is much to be learned about the etiology of sulfonamide toxicity. Losses occurring after prolonged therapy are possibly associated with allergic phenomena, but presumably these were not a factor in the remarkably acute morbidity which occurred at the Spring Creek station.

In the preparation of large quantities of production diets, it is possible that high concentrations of drug might occur if the mixing was not uniform. In the experiments conducted at Spring Creek, the level of medication was probably more accurate than in the production diets, and mortalities or pathology did not occur. However, these fish had been transferred from large production lots to small experimental tanks and quite possibly were not completely acclimated and thus did not consume so much of the medicated feed. The absence of pathology in fish held in the same water supply as the production groups retains considerable significance, nevertheless, and special precautions to prevent incomplete mixing of treated diets are advisable.

These conclusions are substantiated, in part, by the experiments at the Salmon Nutrition Laboratory, where, in a different water supply and with a different group of young salmon, similar pathology and mortalities were produced on high levels of medication. The failure to produce sulfamethazine crystals experimentally in the kidney is unexplained. However, there was no attempt to measure the effectiveness of the methods used to produce dehydration or upsets in osmotic balance, and probably sufficient changes to promote precipitation were not induced.

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EFFECTS OF JAW TAGS OBSERVED UNDER HATCHERY CONDITIONS

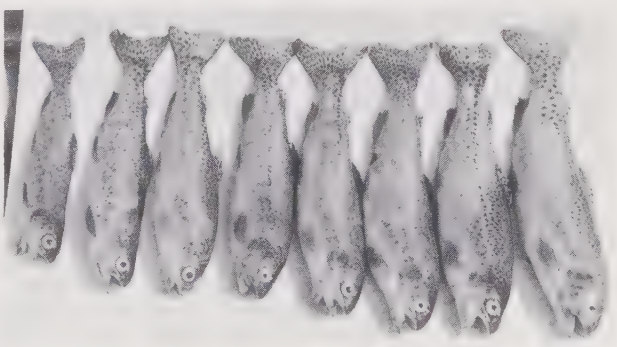
The search for improved methods of identifying individual fish continues. In the past, a monel-metal jaw (band) tag has been used to identify individual trout in some of New Hampshire's open waters. This usage, unfortunately, has provided comparatively few data regarding effects of the tag on the fish. To obtain such information, Bernard W. Corson of the New Hampshire Fish and Game Department observed the effects of the tag on rainbow trout in the hatchery during a 9.5-month period.

Mr. Corson's study was made with 2,000 rainbow trout that had been sorted and resorted from an original lot to form 2 groups of 1,000 fish each. The fish in these groups were similar in weight and size (9 to a pound, with an average length of 6 inches). On October 18, 1955, the trout in the first group were anesthetized, tagged, and released into a concrete raceway. The trout in the second, or control, group were placed in an identical raceway that received unused water from the same source. Each of these 8- by 40-foot raceways had a maintained water level of 14 inches over a floor that was covered with 2 inches of clean, pea-sized gravel. The water flow in each raceway was adjusted to 90 gallons per minute. For each group of trout, the diet and feeding schedule were standardized on the basis of percentage of body weight and water temperature. Careful, direct observations were made until July 23, 1956, when the experiment was terminated.

The growth rates for these groups of trout were very similar, indicating that the tags did not inhibit active feeding or retard growth.

In the test raceway, 22 trout died from natural causes, and 8 lost tags were recovered. In the control raceway, 14 trout represented the total loss.

"On July 23, 1956," Mr. Corson concluded, "the number of fish per pound in the test raceway was 2.98, as compared to 3.03 for the control group. Both lots of fish were in excellent condition, with the exception of the 8 deformities shown in the photograph. These deformities were the result of placing the tag near enough to the distal end of the maxillary to permit free movement over the end of the jaw."



(Photograph courtesy of Mr. Corson)

THE NUTRITION OF TROUT
III. FATS AND MINERALS

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FATS AND MINERALS form two of the major groups of substances that must be represented in the diet of trout.

THE FAT REQUIREMENT OF TROUT

The deposition of fat within the animal body is not necessarily dependent upon dietary fat alone, as body fat may be manufactured from dietary protein and carbohydrate. In establishing the dietary fat requirement of an animal, therefore, it is important to know the source, as well as the role, of body fat.

Functions of Fat in the Animal Body

Little work on the role of fat in trout nutrition has been reported; it must be assumed, for the present, that the information about the role of fats in higher animals also applies to trout.

Basically, fat molecules are composed of carbon, hydrogen, and oxygen, although a few may also contain phosphorus or other elements. These components are chemically linked to form the fatty acids which are the simplest of the fats. The fatty acids are chemically combined with glycerin (three fatty acids to one part of glycerin) to form the common food fats, such as lard and butter, and the oils, such as corn and cottonseed. Through action of the enzyme lipase, these food fats are digested into fatty acids and glycerin before being absorbed by the animal body.

The physical state of a fat is a function of its melting point. A soft fat, liquid at room temperature, is called an oil; and a hard fat, solid before heating, is commonly called a fat. Both fats and oils are called lipides by the chemist to avoid confusion in the term "fat." By chemical methods, oils may be made solid. For example, by the addition of hydrogen to the molecules (the process of hydrogenation), cottonseed oil is made into solid shortening and this and other oils are made into margerine. Soaps are made from fats by the process of saponification; that is, the fatty acids are chemically recovered from the fats, the glycerin is discarded, and the fatty acids are reacted with an alkali to form common household soaps.

Fats are soluble in alcohol, chloroform, carbon tetrachloride, gasoline, and ether. Food and body tissues are analyzed for fat by extracting from the material with ether, evaporating the ether, and weighing the fat that remains. This ether extract is the common value that is used to describe the fat content of foods and animal bodies.

Digested fats are used for several purposes in the animal body. After their absorption, the fatty acids and glycerin are either burned immediately for energy or stored. Stored fat, in addition to serving as a reserve source of energy, insulates the body, provides a cushioning protection for the vital organs, and acts as an internal lubricant.

The animal body contains two types of fat, constant and variable. The constant fat is essential for life and remains in the body even after long periods of starvation. The variable fat increases or decreases according to the food that is eaten.

Until recently, fats were not considered essential for animal nutrition because they could be manufactured by the body from the protein and carbohydrate in the food. Experiments have shown that, for normal health and reproduction, at least one and possibly several specific fatty acids must be in the food. Phospholipides, which are fats that contain phosphorus, are present in all cells of the animal body and are essential for normal growth. Sterols are another group of fats that are essential for life. One of the sterols is made into vitamin D by the action of sunlight on the tissues of plants and animals. In addition to the needs already mentioned, many of the fats are carriers of the so-called fat-soluble vitamins. The diet should contain fats to supply all of these essentials.

In the animal body, fat may be formed from excess food carbohydrate and from food protein that is either of poor quality or present in excessive amount. This fat, which is completely manufactured by the body, represents the natural fat of the animal. Body fat that is deposited from food fat has the characteristics of the food fat. A soft food fat produces a soft body fat, and a hard food fat produces a hard body fat. For example, hogs that are fed peanuts have a body fat that will flow from a tilted pail, but feeding corn to hogs prior to slaughter hardens the body fat so that it yields a marketable lard.

The digestibility of a food fat is largely dependent on its melting point. A fat that is hard at the normal body temperature of an animal is less readily digested than a fat that is soft. Also, hard fats reduce the efficiency of digestion of other foods by coating the particles of protein and carbohydrate and preventing action of the digestive enzymes.

Though fat in the diet is essential, and though some fat within the animal body is necessary, excessive deposition of fat produces an animal that is sluggish and more susceptible to heart attacks, strokes, and other diseases. A fat human being suffers in hot weather and is subject to flat feet, shortness of breath, and lack of stamina. Fat farm animals have less desire to breed and are not desirable as brood stock. Because the liver and kidneys are sites of fat deposition, in excessively fat animals these organs may be damaged. Fatty infiltration occurs, and the cells become swollen. Under such conditions the efficiency of the organs may be impaired to the extent of causing the death of the animal.

The deposition of fat may produce false results when the effect of a feeding program on growth is being measured. The increased weight of a fat animal may falsely indicate excellent growth. Growth should be measured by the production of flesh and bony tissues, not by the production of fat. In making accurate growth studies, it is important to measure flesh production by chemical means, and not to base judgment on the increase in weight alone. Excessive deposition of fat in an animal body is almost always caused by overfeeding. Either the total intake of food is too great, or excessive amounts of one of the fat-producing foods are being eaten.

Fat in the Diet of Trout

As in the higher animals, the digestion of fats by trout is dependent on the melting point. Salmon and cottonseed oils, which are liquid at the body temperature of trout, are about 90 percent digestible. A solid, hydrogenated cottonseed oil is about 70 percent digestible.

Normally, trout-hatchery diets contain between 3 and 5 percent fat. This level does not cause the harmful effects associated with high-fat diets in other animals.

Experiments with trout have shown that high dietary levels of soft fats produce an edema that is characterized by an accumulation of water in the body cavities. This is probably caused by a deposit of fat in the kidney that prevents its normal functions. Both high-fat diets and overfeeding

may cause fatty infiltration of the liver in trout. Fatty-infiltrated livers are pale yellow, swollen, and greasy in appearance. The swelling is caused by deposits of fat in the liver cells. Excessive mortalities occur among trout having extreme fatty infiltration of the liver.

Small trout have difficulty in digesting the hard fats found on beef hearts and livers. These fats plug the intestinal tract, prevent normal elimination, and cause an increase in mortality. Meats fed to small trout should be trimmed of fat before the food is ground.

Three percent cod-liver oil in the diet of trout will cause an increased rate of growth. Experiments have failed to determine which part of the cod-liver oil causes the growth, but there are indications that some of the phospholipides are the growth promoters. Neither of the two vitamins associated with cod-liver oil (vitamins A and D) produces this growth response under experimental conditions. There is some evidence that cod-liver oil should be fed with caution. In higher animals, cod-liver oil, if fed over extended periods, may cause damage to both the kidneys and the liver. So far, difficulties have not been reported for trout, but there is danger. To minimize the possibility of damage, it is suggested that cod-liver oil be fed only during periods of rapid growth, and that this oil be omitted from the diet about 4 weeks before the onset of colder water temperatures.

Experiments have shown that there is more fat in the bodies of hatchery trout than in the bodies of wild trout. Under some conditions, the fat content of hatchery trout drops rapidly after they are stocked in natural waters. The fat of hatchery trout is harder than that of wild trout and changes to a softer fat after the fish are stocked. Experiments with goldfish have shown that a hard body fat has lessened their ability to adjust to both high and low water temperatures. The characteristics of body fat may be a factor in the survival of hatchery trout after stocking. On the basis of the low fat content of hatchery diets and the poor digestion of starches by trout, it has been postulated that the fat in the bodies of hatchery trout comes from food protein that is not utilized for protein purposes. Efficient production of flesh depends on feeding the best possible diets at levels not in excess of the needs of trout.

The principal sources of fats in hatchery diets are cod-liver oil, fish meals, fresh fish, and cottonseed meal. Both fish meal and cottonseed meal are obtainable with low fat contents and should be so ordered for use in trout diets. Fats turn rancid after long storage at the usual temperatures of storage areas. Many fish-culturists believe that rancid fats are toxic to trout. Using concentrates with low fat contents reduces the products of rancidity.

Summary

1. After absorption, fats are either burned immediately for energy or stored. Stored fat is a reserve source of energy, insulates the body, protects the vital organs, and acts as an internal lubricant.

2. Excessive deposits of fat in animal bodies may result in inefficient and unhealthy individuals.

3. In trout, as in higher animals, the digestibility of fats is related to the melting point. Liquid fats are more highly digestible than fats that are solid at the body temperature of the fish.

4. High levels of soft fats in hatchery diets produce a water edema in trout.

5. Both high-fat diets and overfeeding may cause fatty infiltration of the liver in trout.

6. Cod-liver oil in the diet increases the rate of growth of trout but should be fed with caution because of the possibility of damage to the kidneys and liver.

7. Hatchery trout have a higher fat content than wild trout. The fat of hatchery trout is harder than that of wild trout. The level and character of fat in the body may be a factor in the survival of hatchery trout after stocking.

8. Normally, hatchery diets contain between 3 and 5 percent fat.

9. It is commonly believed that rancid fats are toxic to fish. Stored dry

concentrates should have a low level of fat in order to reduce the possibility of high levels of rancid fats.

MINERAL REQUIREMENT OF TROUT

Of all the food groups, minerals have the greatest diversity of uses within the animal body. The study of mineral nutrition is complicated by the difficulty of compounding mineral-free diets. Much is known about the role of minerals in the nutrition of higher animals, but less is known about the mineral requirement of trout.

Functions of Minerals in Animal Body

Minerals are among the basic elements of all matter. Many minerals are essential for the maintenance of life, but not all are needed in the same amounts. For example, relatively large amounts of calcium and phosphorus are needed throughout life, whereas lesser amounts of cobalt and copper are required. Minerals may be divided into two groups: (1) major elements, which are needed in relatively large amounts; and (2) trace elements, which are needed in very small amounts. The amount of a mineral that is needed by the body is not a criterion of necessity, as life cannot exist without either the major or the trace elements. Minerals are distributed throughout the food groups and are usually taken into the body in adequate amounts. There are areas where the soil is deficient in one or several of the minerals, however, and animals (including human beings) that are reared on food grown in these areas must receive supplemental minerals in their diets. If a soil is deficient in a mineral, the plants growing in the soil will be deficient in the mineral and the animals eating the plants will receive quantities that are insufficient to satisfy the body needs, for all animals are dependent on plants as the primary source of all minerals. Persons living where the soil is deficient in iodine may suffer from goiter; supplemental iodine must be used in the diet. If the soil is deficient in iron, it must be added to the diet of farm animals to prevent anemia. Some grazing lands require the addition of cobalt to the soil. The plants store the mineral, and this permits a thrifty growth of cattle when the grass is eaten. Water plants and animals depend on the minerals which are washed from the soil into the water and are thus made available. Under natural conditions, the minerals used by plants and animals of an area are returned to the soil for future generations through the cycle of death, decay, and regeneration. Constant cropping of an area will eventually reduce the supply of minerals, making it necessary to replenish the soil through artificial fertilization.

Chemical analyses are made to determine the minerals in foods. Soils, plants, and animals may be analyzed for an individual mineral or--as is usual for food products--may be analyzed for the total of all minerals. This mineral analysis is made by heating a sample of the material at high temperature for a long period to burn off the organic material. The white, powdery ash that remains is weighed and is regarded as the total mineral or ash content of the sample, without specification of the kinds of mineral. The constituents that have been burned off--the fat, protein, carbohydrate, and water--are separately analyzed. The ash content is a useful measure for comparing mineral potentials of foods and for evaluating the total mineral content of animal bodies fed on different diets.

Minerals may be classified according to use in the animal body. Minerals that are known to be essential--and others that are suspected of being essential, but whose exact role is unknown--may be grouped in the following categories: Structural minerals, respiratory minerals, body regulators, reproductive minerals, minerals for special body processes, and minerals suspected of being essential.

Structural minerals. --These are the minerals that form the hard and the supporting structures of the animal body (the bones and teeth). The principal components of these structures are calcium and phosphorus. These minerals must be fed at a ratio of two parts of calcium to one of

phosphorus: improper balance causes incomplete utilization. Very small amounts of fluorine and magnesium are essential for the formation of bones and teeth.

Respiratory minerals. --The supply of red cells in the blood stream depends on iron, copper, and cobalt. All are trace elements, and a deficiency of any one will cause anemia. Iron, in the presence of copper and cobalt, combines with protein to form hemoglobin, the red-cell material that carries oxygen throughout the body. An anemic animal lacks hemoglobin, so that the oxygen-carrying capacity of its blood is reduced. In a severe case of anemia, the animal dies from suffocation because of insufficient oxygen for normal tissue respiration.

Body regulators. --Minerals play an important role in regulating body processes. Minerals regulate the osmotic pressure of the body cells so that the cells may remain turgid and the body form may be maintained. The regulators of osmotic pressure are sodium, chlorine, and potassium. About 90 percent of each of these elements is found in the body fluids. The occurrence of cramps, caused by copious drinking of water after violent exercise in hot weather, is an example of osmotic upset. Both salt and water are lost in perspiration. When the water alone is replenished by drinking, the dilution of the body fluids causes cramps. The addition of table salt to the drinking water eliminates the cramps by restoring the mineral balance of the body fluids. Sodium, chlorine, and potassium maintain the proper acid-alkali balance in the body. Recently, minerals have been recognized as catalysts, or promoters of certain body processes necessary for normal growth and health. These minerals are needed in small amounts; many of the trace elements probably are in this category.

Reproductive minerals. --Minerals are directly concerned with the successful development of the young in the mother's body. Calcium and phosphorus are needed for the development of the bony parts of the fetus, and other minerals are needed to establish, maintain, and regulate the life of the developing young. The adult requires larger than normal quantities of minerals in the diet during reproduction. The formation of milk increases the need of the mother's body for minerals. The suckling can use for growth only those minerals that were stored in its body during gestation or that are available in the mother's milk.

Minerals for special body processes.--Chlorine, a constituent of gastric juices, is needed for digestion. Calcium is required for blood coagulation. Copper is a constituent of important enzymes. Magnesium and phosphorus activate some of the digestive enzymes; also, magnesium has a specific laxative effect on the digestive tract. Zinc is needed for normal development of the hair and for proper regulation of tissue respiration. Iodine is a component of thyroxine, product of the thyroid gland that regulates the rate of metabolism in the animal body. An iodine deficiency causes goiter, poor growth, and excessive fat. Methionine, an essential amino acid, contains sulphur--as does vitamin B_1, or thiamine. Sulphur is found in hair, nails, and horns, and is generally distributed throughout the body. The phospholipides, which are needed for normal growth, contain phosphorus.

Minerals suspected of essentiality. --In addition to the minerals known to be essential, there are others which appear necessary--but whose exact roles are unknown. It is believed that bromine is necessary for normal development of the young. The amount of arsenic in the blood stream is correlated with pregnancy and menstruation in human beings. There is some evidence that boron may be needed for normal health and growth. Although large amounts of silicon are in the animal body, a silicon-deficient diet has failed to produce pathological effects.

Minerals in the Diet of Trout

Difficulties in experimentation have limited studies of the mineral requirement of trout, and only one mineral deficiency is definitely recognized. As in the higher animals, a deficiency of iodine causes goiter, which may be corrected by adding

a tablespoonful of Lugol's iodine solution to each 50 pounds of trout feed. Although only one mineral deficiency is recognized, it is safe to assume that the minerals needed by higher animals are also needed by trout.

Two percent table salt (sodium chloride) is often added to trout diets. Salt combines with various meat products, such as spleens and livers, to form a rubberlike mass that resists disintegration when the food is placed in the water. Because the diet is "bound," there is a more complete consumption of food by the trout, resulting in a more efficient conversion of food into fish flesh and a faster rate of growth. Excessive levels of dietary salt cause an upset in osmotic regulation of the fish's body, an upset that is characterized by an edema and eventually results in death. In experiments in which salt was fed in capsules to assure complete consumption of the mineral, the body chlorides were increased when 0.91 to 1.82 grams of salt per kilogram of trout weight were fed, and an edema resulted when 2.72 to 3.64 grams of salt per kilogram of weight were fed. In experiments in which salt was mixed with the food, as much as 13 percent of salt failed to produce adverse effects. The probable reason for the difference between the capsule and the feeding experiments is that salt is very soluble, so that it is doubtful that much of the salt added in the feeding experiments was actually consumed by the fish.

Until recent years, the role of dissolved minerals in the water--in connection with trout nutrition and physiology--has been neglected. It has been assumed that minerals must proceed through the normal food chain of the water before they are utilized by trout. Experiments with radioactive isotopes have shown that trout absorb significant amounts of calcium, phosphorus, and cobalt directly from the water, and it may be an important source for these dissolved minerals. There is little doubt that many of the other minerals also enter the trout's body directly from the water. Furthermore, it is known that the amount of dissolved mineral taken from the water will increase if the mineral is lacking in the diet and will decrease if an abundant supply is available. These studies confirm the postulation made some years ago, that inasmuch as the amount of calcium present in the body of hatchery trout is greater than that supplied by the food, trout absorb calcium from water.

Recent work on the role of dissolved minerals in trout physiology has confirmed the early observation that dissolved calcium in water has a direct effect on the osmotic regulation of the trout body. An insufficiency of calcium causes an upset in osmotic regulation, and this upset causes an increase in the metabolic activity of the trout. A copious supply of other minerals in the water does not effect this alteration of metabolism. The levels of dissolved minerals in natural waters may be an important factor in the survival of hatchery trout after stocking.

In general, the foods fed to hatchery trout contain sufficiently high levels of minerals. Fish meal, bone meal, kelp meal, dried skim milk, and meat meals are the best sources of minerals; and fresh meats (liver and spleen) contain many of the trace elements. Trout fed a meat diet while they are held in soft, mineral-deficient waters could conceivably suffer mineral deficiencies. The inclusion of dry concentrates in the diet should eliminate this possibility. There have been experiments in which mineral supplements have been added to the diet of trout. Until more studies are completed, however, it seems unwise to suggest the additional expenditure for supplements. The study of the mineral requirement of trout is incomplete, but it is apparent that both dissolved and dietary minerals are important to the health and vigor of trout.

Summary

1. Minerals essential for life may be divided into major elements, which are needed in relatively large amounts, and trace elements, which are needed in very small amounts.

2. Minerals serve the body as materials for structure, respiration, body

regulation, reproduction, and other special body processes.

3. Only one mineral deficiency is definitely recognized in trout: as in the higher animals, a deficiency of iodine causes goiter in trout.

4. It must be assumed that all of the minerals needed by the higher animals are also needed by trout.

5. Table salt (sodium chloride) at a level of 2 percent is used to bind the diet of hatchery trout.

6. Fed in capsules, salt at rates from 0.91 to 1.82 grams per kilogram of trout weight per day causes an increase in body chlorides, and at rates from 2.72 to 3.64 grams per kilogram of trout weight causes an edema. Mixed in food, salt at levels as high as 13 percent has not produced adverse effects.

7. Dissolved minerals in water are absorbed directly by the fish's body and may be important to its welfare.

8. The calcium in water affects the osmotic regulation of the fish's body. An insufficiency of calcium in water causes an upset in osmotic regulation, and this upset causes an increase in the metabolic activity of the fish.

9. In general, hatchery diets composed of meats and dry concentrates furnish an abundant supply of minerals. Dried skim milk, fish meal, bone meal, kelp meal, and meat meals are the best sources of minerals. Fresh meats, such as spleen and liver, furnish many of the trace elements.

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ACCELERATION OF SPAWNING OF ADULT SALMON

Experimental work on the problem of how to accelerate the sexual maturation of adult salmon was resumed in the Salmon-Cultural Laboratory of the U. S. Fish and Wildlife Service at Entiat, Washington, during the summer of 1956. Injections of gonadotrophins derived from the fractionated salmon pituitary had been ineffective and even deleterious in the 1955 work. The approach to this problem in 1956, therefore, was based upon the physical stimulation obviously received by adult salmon from seasonal variation in the amount of daylight received.

The exposure of blueback salmon to continuous light for a 2-month period prior to their normal spawning time apparently retarded their sexual maturation, for fish so exposed spawned a month later than a control group. As it appeared that exposure to extended periods of light could delay maturation, R. E. Burrows, chief of the Salmon-Cultural Laboratory, undertook to determine whether exposure to abnormally short periods of light would accelerate maturation.

Two months before the normal spawning time, Mr. Burrows placed 84 adult blueback salmon in a pond that received natural daylight exposure and 84 in a pond that received 9.25 hours of artificial light per day. The log of operations for the experiment indicates that spawning began at least 19 days earlier among the salmon exposed to shorter periods of light.

"The analysis of the data is not yet complete," concludes Mr. Burrows, "but the eggs from the experimental females appear to be perfectly normal--although slightly smaller than those of the control fish."

Date (1956)	Number of days	Control pond	Reduced-light pond
July 18	0	Pond stocked	Pond stocked
Aug. 23	36	----------	First female spawned
Sept. 10	54	----------	62 percent of females spawned
Sept. 11	55	First female spawned	----------
Sept. 25	69	----------	Spawning concluded
Oct. 2	76	36 percent of females spawned	----------

TWO-YEAR STUDY OF MOVEMENTS OF STOCKED BROOK TROUT AND RAINBOW TROUT IN A MOUNTAIN TROUT STREAM

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THE EXPECTED MOVEMENT OF STOCKED FISH is an important item to consider in the stocking of many streams. This paper has been prepared, therefore, to contribute to the general knowledge of fish movements and some factors influencing the movements of hatchery-reared fish in a wild environment.

The area in which these fish were stocked is a 3-mile portion of the 25-mile Swift River in Albany County, New Hampshire. This river is a scoured mountain trout stream. Showers during the summer occasionally cause the water level to rise 3 feet or more. As is usually true in streams of this type, food is scarce. Deep snows cause heavy spring runoff, and cold high waters generally prohibit stocking before the latter part of May. Water temperatures seldom exceed the optimum for brook trout and then usually for only a few hours. Wild and "carryover" trout are rare in that portion of the river that is stocked.

The movements of brook trout (Salvelinus fontinalis) and rainbow trout (Salmo gairdneri) were studied in 1953 and 1955. All fish used in this study were marked with serial-numbered jaw tags, and records were made of the exact locations in which the fish were stocked. The spot-planting method--rather than the scatter-planting method--of stocking was used. A creel census was employed to determine the point of capture whenever possible. Often anglers were unable to state exactly where each fish was taken; however, this report includes only information from those who knew exact locations of capture.

In 1953, data were collected on movements of 781 brook trout and 358 rainbow trout. In 1955, it was possible to obtain information on 302 brook trout and 203 rainbow trout.

It may be seen in the table that, with the exception of those fish stocked in May and the one planting of brook trout on June 24, 1953, the largest percentage of the fish stocked tended to be captured in the immediate vicinity of original release. It may also be seen that in all plantings brook trout exhibited a greater tendency to move than did rainbow trout. Although the moving fish exhibited a greater tendency to move downstream, this trend was at least partially balanced by movement in the opposite direction. It may also be seen in this table that fish stocked in the cold water (all May stockings) exhibited a greater tendency to move than did those stocked in warmer water. No explanation can be found for the movement of brook trout stocked on June 24, 1953, and no correlation can be found between fish movements and relative water levels.

The distance-frequency graphs (figures 1-A, 1-B, and 2) show the movements of these fish during the 2 years of study. It will be noted that the largest percentage of fish tended to remain in the vicinity of stocking, and most of the fish that moved stayed within three-quarters of a mile of the point of stocking.

Ratledge and Cornell (1953), in their study of three rainbow trout streams in

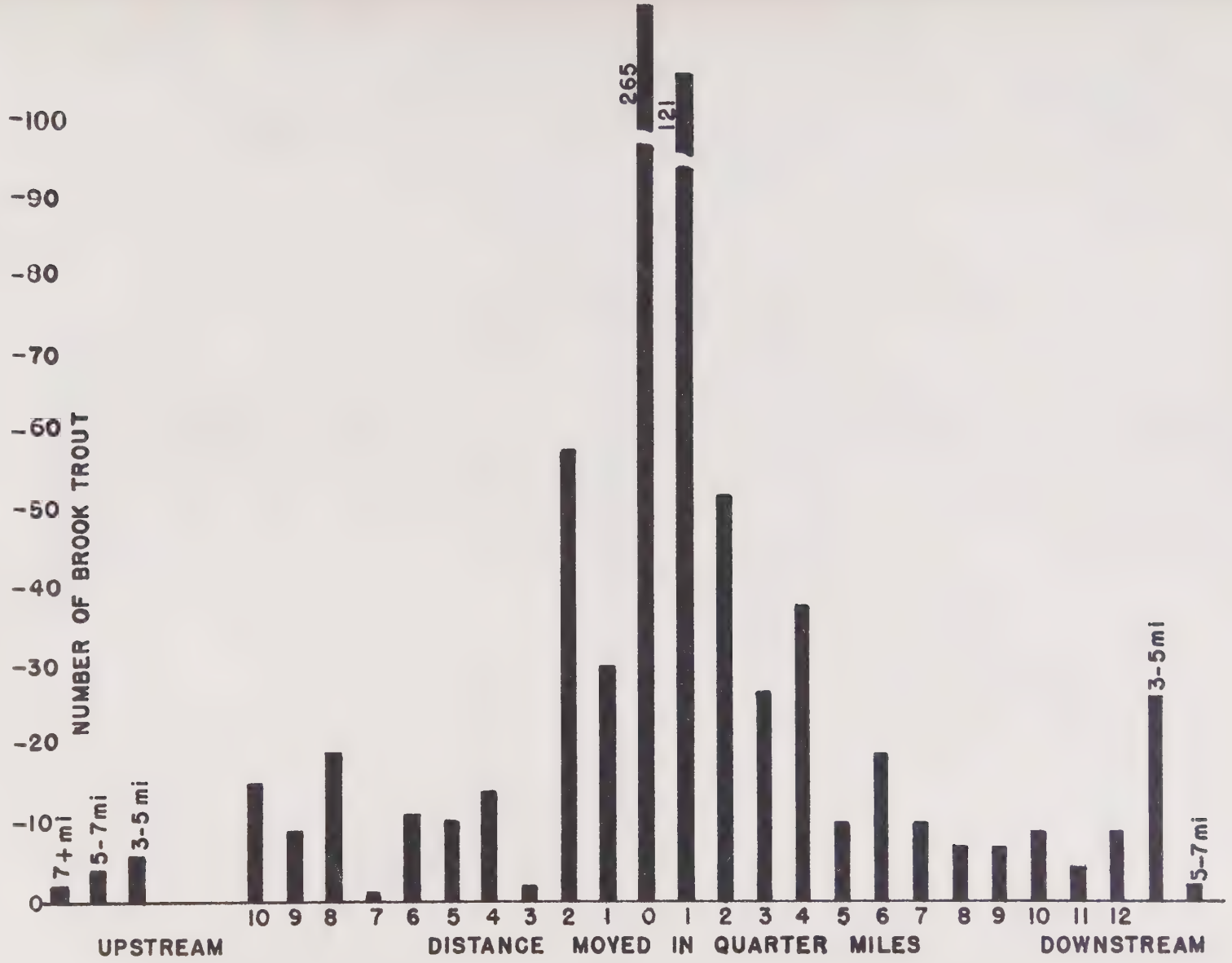


FIGURE 1-A.--Movement of brook trout, 1953.

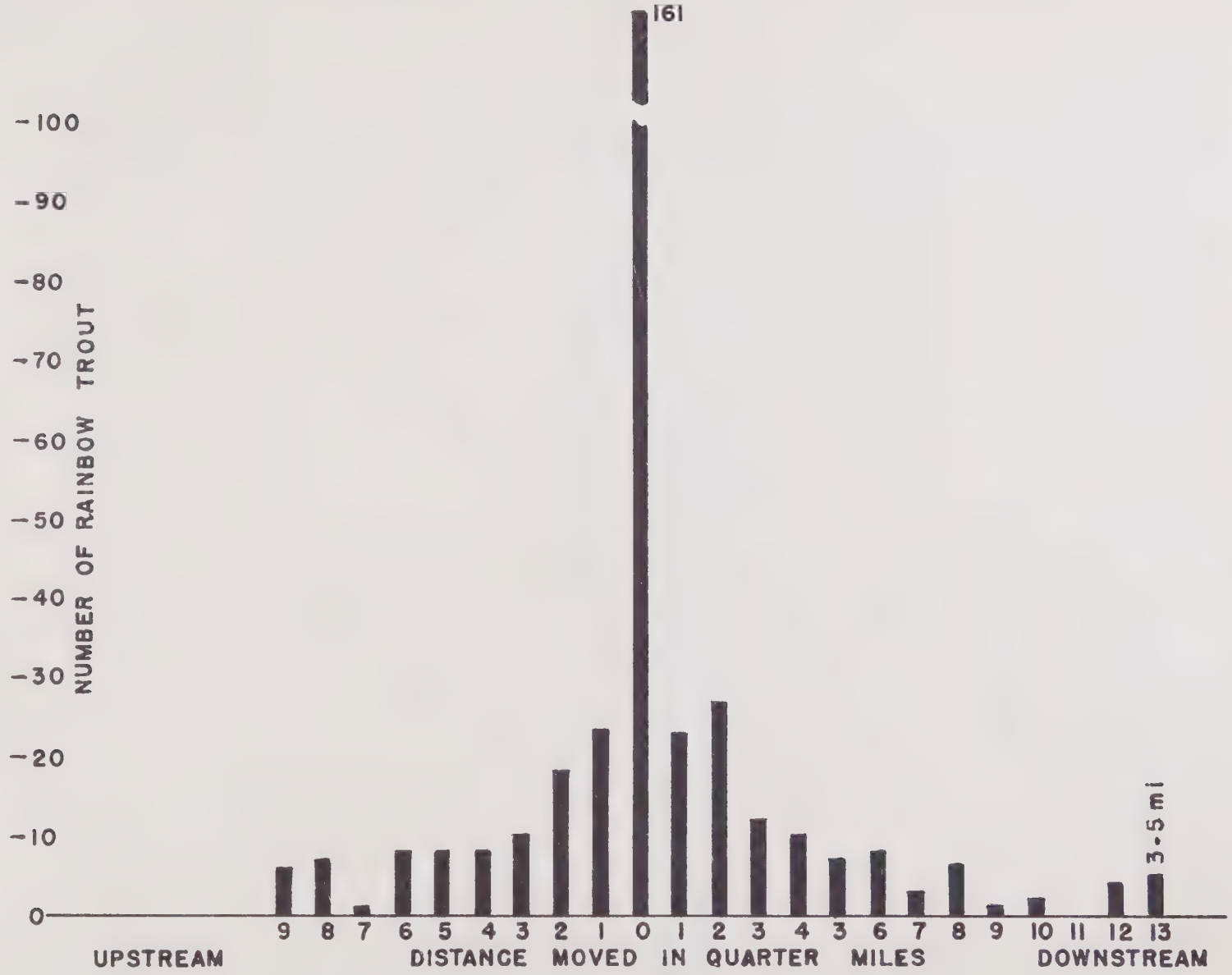
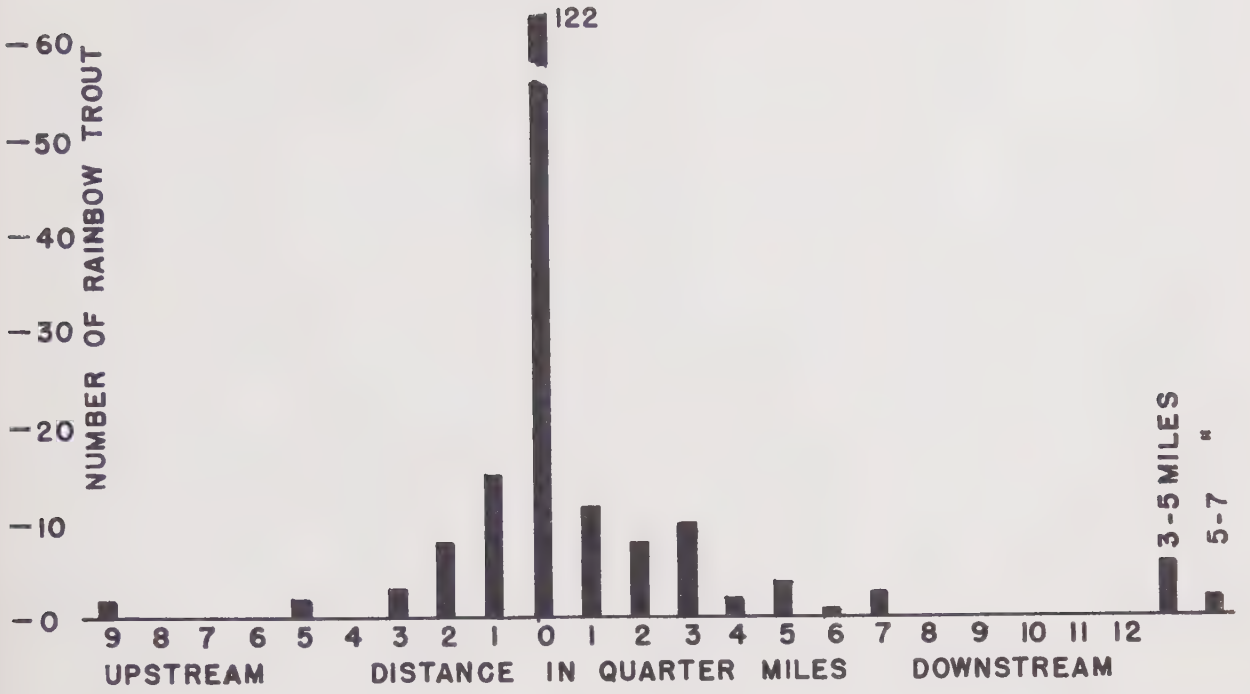


FIGURE 1-B.--Movement of rainbow trout, 1953.



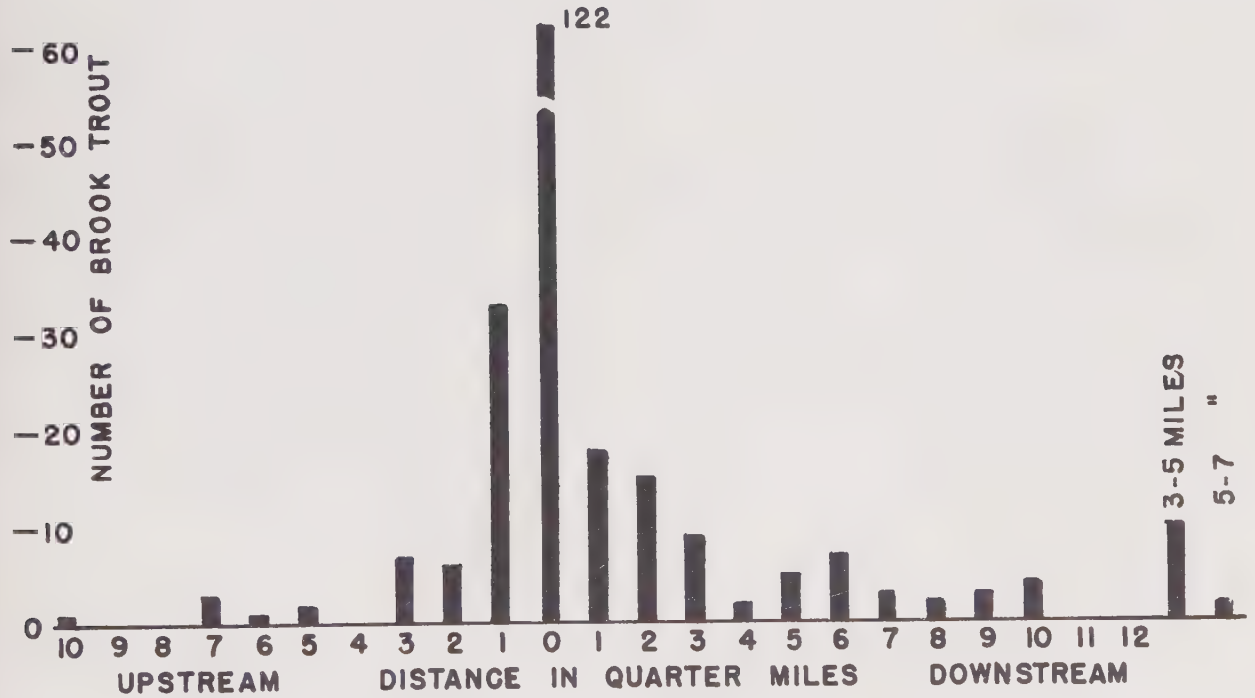


FIGURE 2.--Movement of rainbow and brook trout, 1955.

(All figures courtesy of the author)

Virginia, reported that there was a slight general migration trend in a downstream direction, but that most rainbows were recovered in the vicinity of the stocking point. A study made on the Big Laramie River, in Wyoming (Anonymous 1955), showed that, of the tagged hatchery fish recovered by angling and electrofishing, about half were within 1 mile of where they had been put into the stream. Cooper (1953) demonstrated that rainbow trout and brook trout planted when water temperatures were less than 50° F. exhibited an immediate downstream movement, but that when water temperatures were above 50° F. at the time of planting, fish showed very little movement.

Movements of stocked brook and rainbow trout

Planting date	Water temperature[1] °F.	Percentages: Moved upstream	No movement	Moved downstream
	Brook trout			
May 25, 1953	50	16.1	22.0	61.9
June 24, 1953	63	41.3	27.5	29.8
Aug. 12, 1953	62	18.6	50.8	30.5
May 12, 1955	43 - 50	6.5	37.0	56.5
June 22, 1955	56 - 64	14.5	51.6	33.9
Aug. 16, 1955	64 - 70	28.5	53.3	18.2
	Rainbow trout			
May 26, 1953	52	21.9	39.4	38.5
June 30, 1953	70	27.4	44.2	28.3
Aug. 13, 1953	64	15.9	70.4	13.6
May 13, 1955	46 - 49	18.8	45.8	35.4
June 21, 1955	58 - 62	13.8	64.9	21.3
Aug. 19, 1955	62 - 65	14.5	61.3	24.2

[1] Time of planting in 1953; daily range in 1955.

Discussion

From the foregoing it may be seen that low water temperatures apparently have a decided influence on the movements of stocked trout, and that flow may have little or no influence on the movements of these fish. There is need for additional study, however, with regard to the effects of high temperatures, flow, population densities, competition, and so forth on the movements of stocked trout.

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Study of the seaward migration of salmon at Bonneville Dam has revealed that there is considerable variation in the rate of travel of the fish. A marked blueback salmon required only 8 days to cover the 400 miles between its point of release and Bonneville Dam. Two other salmon from the same hatchery release made the same journey in 13 and 14 days, respectively. A fourth salmon, however, took 877 days to reach the dam.

USE OF ANTIBIOTICS IN THE DIET OF SALMONID FISHES

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A REVIEW OF THE EFFECTS OF ENRICHING THE DIET OF FISHES WITH ANTIBIOTICS has been published recently (Müller 1956). It is very interesting to note that, without exception, the addition of antibiotics to the diet of fingerlings had no significant effect on the growth rate of the fish. This is in contrast to the results obtained with higher vertebrates, such as chickens, young pigs, and calves.

It is generally accepted by nutritionists and microbiologists that the beneficial effects of the presence of antibiotics in animal feeds is caused by changes in the intestinal flora of the animals. Warm-blooded animals harbor in their intestinal tracts a tremendous number of micro-organisms. Though some of these micro-organisms are beneficial, others compete with the host for food or may even be harmful. Unlike higher vertebrates, fish do not have a "normal" bacterial flora in their intestines. When the intestines of a healthy fish are free from food, those intestines are nearly sterile. Therefore, the addition of antibiotics to fish food cannot affect the composition of the "normal" bacterial flora of fishes. This may explain why the addition of antibiotics to the diet for normal and healthy fish does not seem to have any beneficial effect.

The table presented on the following pages is a summary of the material listed in Müller's review table (1956), to which has been added a compilation of the results reported by American authors. It is believed that an assemblage of all the available information on this subject may be of value and interest to fishery biologists and fish-culturists.

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A REVIEW OF THE EFFECTS OF DIETS ENRICHED WITH ANTIBIOTICS AND RELATED SUBSTANCES ON THE GROWTH OF FISHES

Authors	Species of fish tested	Nature of the diet additive	Results
		A. Adapted from a review by Wolfgang Müller (1956: 111)	
Wolf, 1952	Brown trout (Salmo trutta)	1. Aurofac: Chlortetracycline (Aureomycin) with Vitamin B_{12} 2. Terramycin	No significant increase in weight or rate of growth. Slightly lower mortalities.
Berke, Silver, and Kupperman, 1953	Guppy (Lebistes reticulatus)	Chlortetracycline	Size and weight smaller than in the controls.
Wagner, 1954	Rainbow trout (Salmo gairdneri)	1. Oxytetracycline (Terramycin) 2. Chlortetracycline 3. Penicillin 4. Chloramphenicol	All additives decreased the growth rate. Chlortetracycline had the most pronounced effect.
Herald, Dempster, and McCully, 1954	Chinook salmon (Oncorhynchus tshawytscha)	Aurofac	Depressed rate of growth and increased mortalities.
Schreiter, 1954	Rainbow trout	Betapan (product containing vitamins, including B_{12} and Chlortetracycline)	No beneficial results were observed.
Engelhardt and Mann, 1955	Rainbow trout	1. Aurofac 2. Dried mycellium containing penicillin, with addition of procain penicillin	The rate of growth and mortalities the same as in the controls.

A REVIEW OF THE EFFECTS OF DIETS ENRICHED WITH ANTIBIOTICS AND RELATED SUBSTANCES ON THE GROWTH OF FISHES.--Continued

Authors	Species of fish tested	Nature of the diet additive	Results
		B. Compiled by S. F. Snieszko	
Robinson et al., 1951	Sockeye salmon (Oncorhynchus nerka)	1. Animal protein factor containing Vitamin B_{12} 2. Product containing Vitamin B_{12} and Chlortetracycline	No beneficial effect on the growth rate.
Phillips et al., 1952	Brown trout	1. Chlortetracycline 2. Oxytetracycline 3. Penicillin 4. Bacitracin 5. Vitamin B_{12}	No beneficial effect on the rate of growth, conversion factor, or mortality.
Phillips et al., 1953	Rainbow trout Eastern brook trout (Salvelinus fontinalis)	1. Chlortetracycline 2. Penicillin	No beneficial effect from penicillin. Chlortetracycline depressed the rate of growth.
Halver[1/]	Chinook salmon	1. Penicillin 2. Aurofac	Depressed rate of growth.
Snieszko and Friddle[2/]	Brook trout	1. Oxytetracycline 2. Chlortetracycline 3. Chloramphenicol	None had any noticeable beneficial effect.
Schumacher, 1955	Brown trout	1. Chlortetracycline 2. Chlortetracycline with thiamine	No beneficial effect has been observed.

[1/] John E. Halver, U. S. Fish and Wildlife Service, Salmon Nutrition Laboratory, Cook, Washington. Private communication, 1952.

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HANDLING MINNOWS IN PERFORATED PLASTIC BAGS

One of the problems in the culture of fish is to find ways and means of reducing their handling to a minimum. It is well known that excessive handling of some small fish, such as the bait minnows, contributes directly or indirectly to high mortality from a number of causes, i.e., fungal infection and bruising.

Francis H. Bezdek, biologist in the employ of the Soil Conservation Service at Lisbon, Ohio, has found that the need to handle bait minnows can be reduced considerably through the use of perforated plastic (polyethylene bags).

Reporting on his experience with fathead (Pimephales promelas) and bluntnose (Hyborhynchus notatus) minnows in plastic bags, Mr. Bezdek writes:

"Fathead and bluntnose minnows that were from 2 to 3.5 inches in length were weighed by liquid measure in 2-pound lots (approximately 500 fish) and poured into 8- by 15-inch plastic bags--which were held with all but the opening below the waterline. Perforations (3/16- to 1/4-inch) had previously been made in these bags to allow free circulation of the water. The bags were closed with rubber bands and then permitted to drift at random in holding tanks and small ponds until they were retrieved for call customers or for delivery to bait dealers.

"In transit, as many as 3,000 fish (6 bags) were placed in 0.5 cubic foot of water at 50° to 55° F. and were held for 2 hours with no artificial aeration--and without apparent stress. The same number of unconfined, free-swimming fish in the opposite end of the same container, however, showed considerable stress.

"A noticeable feature peculiar to bag-confined minnows was that their continued attempts to escape--the swimming action, concentrated into a small area--tended to 'boil' or agitate the water and thus to aerate it.

"There has been no attempt to determine how long fish can be held in these bags," concludes Mr. Bezdek, "but on several occasions fish were held for 24 to 48 hours successfully."

POSSIBLE VALUE OF CONTINUOUS FEEDING OF MEDICATED DRY DIETS TO PREVENT AND CONTROL PATHOGENS IN HATCHERY-REARED TROUT

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IN MICHIGAN, AND IN GENERAL WHEREVER TROUT ARE REARED UNDER HATCHERY CONDITIONS, a disease of bacterial origin (Aeromonas salmonicida), commonly known as furunculosis, has caused serious epidemics. McCraw (1952) stated that no fish disease is more to be feared by the hatcheryman than furunculosis. The disease appears to act more severely on certain trout species than on others. In Michigan, brown trout (Salmo trutta) are more susceptible than others, and brook trout (Salvelinus fontinalis) are next. Many other species of fish contract furunculosis, but in them the disease reaches epidemic status less frequently than in brown or brook trout. A method of treatment often used is to feed a mixture of sulfaguanadine and sulfamerazine with the daily food ration.

In hatcheries where furunculosis frequently reoccurs, it is often necessary to feed successively higher levels of sulfa drugs for adequate treatment or control. Because of this, it may be safe to assume that the particular strain of pathogen becomes somewhat resistant to the drug, and that if the progressive increase in the level of drugs administered continues, the host could be adversely affected before the drug acts on the pathogen. It would seem that medicaments of mild chemical and physiological nature, adapted to continuous feeding, could offer a means for controlling this disease indirectly; that is, by reducing the number of organisms of low pathogenicity in the intestinal tract. In other words, "cleaning up" the intestinal tract may be all the chemotherapy needed to prevent a serious outbreak of furunculosis.

In order to test this hypothesis, it was necessary first to select a drug or group of drugs that could be used for continuous feeding without adversely affecting the animal in general.

In investigations conducted with warm-blooded animals, it has been found that a group of antibiotics can be fed continuously and effectively, and that benefit is derived from this practice. Antibiotics have been found to (1) differ in structure and biochemical activity, (2) have considerable variance in spectra, (3) be compatible to other diet ingredients when mixed together, and (4) be essentially nontoxic even in excess quantities. Besides suppressing organisms that cause subclinical diseases, antibiotics work to suppress intestinal organisms that compete with an animal for vitamins in the food it eats (Jukes 1955), and thin the walls of the intestine, permitting better absorption of vitamins and nutrients in the body. 1/

1/ Gordon, H. H. A morphological and biochemical approach. (Colloquium) Studies on the growth effect of antibiotics in germ-free animals. Lobund Instit., Univ. Notre Dame, South Bend, Ind. June 4, 1952.

This group of drugs appeared to provide the physical and chemical qualifications necessary to test the hypothesis previously stated.

Recently a new type of trout food was adopted by the State of Michigan. It consists of animal and vegetable meals pelleted in various sizes. Food in this form offers several advantages for the introduction of medicaments to trout. Medicated diets in pellet form can be stored for several months at each hatchery, thus assuring an adequate supply at all times. Daily mixing of drugs with other diet ingredients can be eliminated. Drugs can be mixed more uniformly in dry-meal diets, and this gives better control of amounts fed.

In 1953, a broad-spectrum antibiotic, aureomycin, was mixed with dry meals and pelleted. An animal-feed supplement containing 10 grams of Chlortetracycline-Aureomycin per pound was used at a 1-percent level, furnishing 200 grams aureomycin activity per ton of finished feed. (This level was found to be compatible in poultry feeds.) The diet was fed for a 6-month period to rainbow and brook trout fingerlings to determine the gross effect of aureomycin as a trout-food additive. All trout reacted favorably, and it was not possible to attribute any advantage or disadvantage to the presence of the drug in the diet.

Previous experiments at other stations also failed to show any beneficial effects from feeding antibiotics to trout. Schumacher (1955) demonstrated (by Chi-square) no statistically significant differences in the effect of aureomycin on the growth rate of brown trout fingerlings. Phillips, Lovelace, Brockway, and Balzer (1952) concluded from experiments with brown trout that aureomycin, terramycin, penicillin, and bacitracin had no beneficial effects on growth, conversion, or mortality. In one test Phillips found that aureomycin depressed the growth rate of rainbow trout. Wagner (1954) demonstrated that rainbow trout lost weight during the first 2 weeks of feeding penicillin or aureomycin.

In disease-prevention studies Snieszko (1952) demonstrated that aureomycin was ineffectual when used to treat brook trout artificially injected with Aeromonas salmonicida. In vitro, aureomycin did inhibit the growth of this pathogen, but the effect was not so pronounced as that of chloramphenicol or terramycin.

To determine whether furunculosis could be controlled by continuous feeding of mild medicaments, it was necessary to wait for the disease to appear as a natural infection (rather than through mechanical injection of the pathogen), so that the condition would be more representative of that occurring during normal hatchery operation. It is suspected that Aeromonas salmonicida is constantly present in hatchery water supplies where repeated outbreaks of furunculosis occur, although it is possible to rear trout in such waters. Thus, either the fish are more resistant physiologically at one time than another, or the pathogen is not able to exert its full destructive force at all times because of variations in environmental conditions or, particularly, variations in intercurrent subclinical infections. Therefore, it might be expected that injecting fish with pathogens to produce an artificial epidemic would produce results less valid than those from fish that contracted furunculosis from endemic contamination.

As it had been demonstrated that normal rainbow and brook trout were not appreciably affected by continuous feeding of aureomycin at a certain level, a diet containing this drug was kept in stock, ready for instant use in the event that furunculosis appeared in any group of trout.

An opportunity to test the disease-prevention properties of aureomycin was presented on September 3, 1955, at the Wolf Lake, Michigan, hatchery. Furunculosis was detected in a group of 2-year-old brook trout. These trout had been reared in concrete tanks since hatching and had been sustained on an all-dry-meal diet. Immediately upon detection of the disease, all trout were counted. Half of the group, 106 in number, were left in the original tank; the other half were placed in an adjacent tank. A pelleted diet containing 200 grams of aureomycin per ton of

feed was used for the medication. The group of 106 in the original tank were fed the medicated diet in amounts equal to 1.7 percent of body weight per day; the other group continued to receive, at the rate of 1.7 percent of body weight per day, the pelleted diet fed before the disease was noted. The experiment was in effect 2 hours after the disease was detected.

During the experiment, September 1955 to March 1956, both lots of fish were artificially spawned and the fertilized eggs incubated in water at 42° F. At the time of spawning, the medicated group had been fed aureomycin continuously for 2 months.

PERCENTAGE SURVIVAL OF BROOK TROUT INFECTED WITH FURUNCULOSIS, AFTER FEEDING ON A DIET MEDICATED WITH AUREOMYCIN, AND ON A NONMEDICATED DIET

Date	Medicated diet		Nonmedicated diet	
	Number surviving	Percentage	Number surviving	Percentage
Before spawning				
1955				
Sept. 3	106	100	106	100
Sept. 30	101	95	101	95
Oct. 31	93	88	96	91
Nov. 18	88	83	62	58
After spawning				
1955				
Nov. 30	87	82	48	45
Dec. 31	78	74	30	28
1956				
Jan. 31	67	63	26	25
Feb. 29	60	57	22	21

There was a wide difference in the number of fish surviving in the two groups (see table). On November 18, 1955, 83 percent of the brook trout that were on the medicated diet survived, whereas only 58 percent of the fish on the nonmedicated diet were still alive. On February 29, 1956, these percentages were 57 and 21, respectively. Thus it appears that aureomycin contributed to the well-being of the fish afflicted with furunculosis. As the only known variable in the diet was the aureomycin, there is a good chance that the medicated diet assisted recovery of those fish already afflicted and/or served as a preventive in those fish not yet under the influence of rapid multiplication of bacteria. Because fish in both groups were spawned, some mortality must be attributed to rough handling during this operation. However, the two groups were handled in a similar manner; therefore, it is unlikely that the observed difference in mortality was due to spawning operations alone.

Fifty-eight percent of the eggs produced by fish that were on the medicated diet hatched, whereas the hatching percentage was 23 for eggs from fish on the regular diet. These data indicated that egg production and fertilization were possible in fish suffering from furunculosis, and that continuous medication by feeding aureomycin for 2 months before spawning did not adversely affect fertilization and hatchability.

As these data are based on only one experiment and two groups of animals, the work must be considered as preliminary. Therefore, feeding trials, using some of the other antibiotics for continuous medication, should be conducted before recommendations are made.

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EXCERPT: THE VITAMIN REQUIREMENT OF BROWN TROUT

From the data ... all vitamins omitted from the synthetic diet are necessary growth factors for brown trout (inositol, B_{12}, niacin, pyridoxine, choline, riboflavin, folic acid, and biotin).

Only a deficiency of three of the vitamins results in an increase in mortality of the trout. The absence of pyridoxine from the diet causes the death of all trout within 14 weeks. The removal of either riboflavin or biotin causes an increase in trout loss but less severe than the omission of pyridoxine.

Blood counts fail to show anemia in any of the trout in these studies. ...

In comparison to the control diet, the complete synthetic diet produces satisfactory results with brown trout in this type of study.

Although eight members of the vitamin-B complex are needed for normal growth and to prevent mortality of brown trout, only a deficiency of biotin results in recognizable deficiency symptoms. "Blue-slime" or "slime-patch" disease is apparent on brown trout lacking biotin in the diet. Since a lack of seven other vitamins affects the growth of brown trout, and since no symptom is recognizable to indicate which of the vitamins may be concerned, it is necessary to include all of the vitamins in all diets to assure normal growth and to prevent excessive mortalities of the trout. Experience indicates that either 5 percent dried brewer's yeast or 20 percent beef liver in the diet will satisfy the requirement of the trout for these members of the vitamin-B complex.

Future studies should include an investigation of the vitamin-B requirement for both lake trout and Atlantic salmon. The completion of these studies would provide knowledge of the vitamin-B requirement for all of the cold-water species of fresh-water fish cultured on the east coast.

-- Discussion, "The Vitamin Requirement of Brown Trout": The Nutrition of Trout, Cortland Hatchery Report 24 -- A. M. Phillips, Jr., F. E. Lovelace, H. A. Podoliak, D. R. Brockway, and G. C. Balzer, Jr.- N. Y. Cons. Dept., Fish. Res. Bull. 19, 56 pp., illus. 1956.

Many fishery workers are convinced that scales calibrated in pounds and tenths of pounds, rather than ounces, are time-savers.

RELATIVE SENSITIVITY OF SALMONIDS TO DDT

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A COMPLETE LOSS occurred in 25,000 landlocked salmon (Salmo salar) hatchery fingerlings (1-inch) being reared by a commercial fish hatchery for the Adirondack League Club of Old Forge, New York. As some experimental work was being done in cooperation with Cornell University, this agency had a particular interest in the cause of death.

Mortality occurred suddenly and extended over only 3 days late in March. Prior to this time mortality had been negligible. No direct examination of fish or water supply was made, but the general mortality curve suggested that factors other than micro-organisms were involved. Brook trout (Salvelinus fontinalis) in the same hatchery suffered no unusual mortality, although rainbow trout (Salmo gairdneri) showed some increase in mortality. Airplane spraying of DDT in the hatchery watershed was suspected as a potential source of mortality.

Mortality caused by DDT has recently been reported in Atlantic salmon parr (Kerswill and Elson 1955), but apparently there is no information on the relative sensitivity among salmonids under similar environmental conditions. This prompted the small-scale tests reported here.

Initial Test

Fingerlings of the three species were available at the Cornell University Experimental Fish Hatchery in the spring of 1956: landlocked salmon that averaged 1.4 inches in total length; brook trout, 1.6 inches; and rainbow trout, 1.3 inches. All fish were progeny of wild parents that had been hatched and reared at the Cornell Hatchery.

Six fish of each species were placed in each of 7 aquaria. The aquaria were immersed in a hatchery trough to maintain a reasonably uniform temperature. Water temperatures ranged from 69° to 73.5° F. during the experiment. Aquarium water was not aerated, and the density of the test fish was high for the temperatures encountered.

The toxicant used was a mixture commonly employed in black-fly control, consisting of 20 percent DDT and 20 percent AR-50 by weight in fuel oil. Five liters of test solution were placed in each aquarium. Concentrations of 0.08, 0.16, 0.32, 0.50, 1.00, and 10.00 p.p.m. were used. The seventh aquarium served as a control. Observations were made hourly from 8 a.m. to 11 p.m.

Long before death, salmon and brook trout showed symptoms of DDT poisoning similar to those described by Everhart and Hassler (1948). In every instance, salmon were the first to show distress. Brook trout were somewhat slower, and rainbow trout showed few signs of distress until immediately before death.

In only one concentration (0.50 p.p.m.) did the death of another species precede the death of a salmon. In 4 of the 6 test aquaria, all salmon died before any brook trout succumbed. At concentrations of 0.08 and 0.16 p.p.m., all salmon were killed in 36 hours without the loss of any brook trout. At 0.32 p.p.m., all salmon were killed in 36 hours, though 50 percent of the brook trout remained alive. At concentrations higher than 0.32 p.p.m.,

all fish were killed in less than 36 hours. Rainbow trout tended to be somewhat less sensitive than salmon, although results with the former were erratic. Testing was discontinued at the end of 72 hours, at which time the following fish remained alive: in the control aquarium, 2 rainbow trout and 4 brook trout; in the aquarium containing DDT at a concentration of 0.08 p.p.m., 1 rainbow trout and 3 brook trout.

Final Test

The experiment was repeated for DDT in concentrations of 0.08 and 0.16 p.p.m., with a control, to confirm the initial implications and remove possible effects of oxygen deficiency. The size differential may have had some influence on the results obtained, but this is not a completely satisfactory explanation.

Ten fish of each species were placed in 20 liters of test solution supplied with continuous oxygen. Test fish were from the same lots used previously. Sizes were more carefully selected, and the following averages resulted: landlocked salmon, 2.0 inches; brook trout, 2.1 inches; and rainbow trout, 2.0 inches in total length. (Standard deviation was 0.1 inch in each group.) The same toxicant was used, and temperatures were maintained in the same manner. Water temperatures ranged from 65° to 71.5° F. Observations were made every 2 hours for a 72-hour period.

Results of the final experiment have been summarized in the table. Symptoms of poisoning were similar but did not occur so early as in the initial experiment. At the end of 72 hours, the following fish were alive: in the control aquarium, 10 landlocked salmon, 3 rainbow trout, and 10 brook trout; in the aquarium containing DDT at a concentration of 0.08 p.p.m., 10 landlocked salmon, 6 rainbow trout, and 7 brook trout. No fish survived in 0.16 p.p.m. DDT.

It seems evident that landlocked salmon are more sensitive to DDT than either rainbow or brook trout. Though the initial experiment indicated that all the levels of DDT tested were toxic, it is apparent from the final test that oxygen deficiency was also a factor. The data suggest that, under conditions of oxygen saturation, there is a level of DDT concentration between 0.08 and 0.16 p.p.m. that is lethal for landlocked salmon but sublethal for rainbow and brook trout.

The reason for high mortality of rainbow trout in the control aquarium in the final test is unknown. Another group consisting of 10 fish of each species was subjected to the same measurement procedures as the test fish. Rainbow trout and landlocked salmon were measured under ether anesthesia. This group was kept under normal hatchery conditions (except the feeding) for the duration of the test without mortality. Because of the erratic response of rainbow trout to test conditions, it is impossible to assign a relative sensitivity to this species.

Acknowledgment

Dr. D. A. Webster, associate professor of fishery biology, Cornell University, suggested the problem. Dr. J. E. Dewey,

Time before death due to DDT toxicity in three salmonid species, final test

DDT concentration (p.p.m.)	Hours until-- First death			50 percent mortality			100 percent mortality		
	Landlocked salmon	Rainbow trout	Brook trout	Landlocked salmon	Rainbow trout	Brook trout	Landlocked salmon	Rainbow trout	Brook trout
Control	Over 72	24	Over 72	Over 72	28	Over 72	Over 72	Over 72	Over 72
0.08	Over 72	26	36	Over 72	Over 72	Over 72	Over 72	Over 72	Over 72
0.16	7	13	18	10	22	21	18	54	26

professor of insect toxicology, furnished the DDT. W. L. Hartman and P. C. Neth gave assistance in the conduct of the tests. Dr. Webster and Mr. George Burdick of the New York Conservation Department reviewed and commented upon the manuscript.

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STUDIES ON TILAPIA IN TAIWAN

Tilapia mossambica has become widely known, and its propagation has spread to many Asiatic countries. In Taiwan, however, where the climate is temperate to semitropical, the culture of this tropical fish has presented some difficulties.

The development of a variety of Tilapia better adapted to the climatic conditions of the country has been judged necessary for greater success in the culture of this popular fish. Therefore, physiological and ecological studies of the Tilapia have been in progress at the Taiwan Normal University for the past 4 years. Recently the Joint Commission on Rural Reconstruction at Taipei, Taiwan, has reported some data obtained during these studies.

Studies on the effects of high and low temperature on sperm indicate that it may be possible to breed a Tilapia that has greater resistance to cold. This resistance of the sperm to low temperature is shown in the following summary of tests:

°C.	Effect
36 - 38	Motile after 24 hours.
40	Nonmotile after 0.5 hour; dead after 2 hours.
44	Dead within 15 minutes.
4 - 8	Motile.
3	Activity slowed after 0.5 hour; dead after 2 hours.
1	Nonmotile.
0	Dead after 5 minutes.

Studies on hydrogen-ion concentration have revealed that the pH value that is most suitable for the sperm is 5.4, at which they have remained alive for 48 hours. Nevertheless, any pH value from 4.2 to 6.8 permitted the sperm to live for 4 to 5 hours. Even at pH 8.2, they remained alive for more than 1 hour.

The specific gravity for the Tilapia egg has been demonstrated to be from 1.080 to 1.095. Among 4 fish that were tested, the fat content of the egg ranged from 19.5 to 30.1 percent.

Incubation studies, and particularly the trial of three different arrangements of the incubating facilities, have demonstrated that the Tilapia requires a good supply of oxygen for the development of eggs. Healthy, artificially fertilized eggs were placed in three sets of jars that received water at a temperature ranging from 25° to 28° C. The group of eggs placed in jars that were under a gentle stream of water, with sufficient flow of water to roll those eggs, hatched in 114 hours. On the other hand, the group of eggs placed in jars that received merely frequent changes of water, like the group of eggs placed in jars that did not receive any change of water, failed to hatch. This finding is regarded as consistent with the mouth-breeding of the Tilapia and indicative of a high rate of metabolism.

SOME EXPERIMENTS IN CHANGING POPULATION BALANCE IN FARM PONDS

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DURING A STUDY OF FARM PONDS IN MARION COUNTY, IOWA, SEVERAL ATTEMPTS were made to improve the population balance by supplemental stocking of bass and/or bluegill, by thinning the population with the seine, and by treating with rotenone to eliminate the fish and start over.[1/] As livestock have priority for use of the water in most Iowa farm ponds, it is generally not possible to drain and restock ponds that contain unsatisfactory fish populations. Before a discussion of the effectiveness of the various attempts to improve the populations, a few remarks on the method of determining population balance or success in a pond are in order.

The Minnow-Seine Technique as an Indicator of Pond Success

The minnow-seine technique described by Swingle (1945) was used in the preliminary inspection of the Iowa ponds. Judged entirely on the basis of what the minnow-seine technique revealed during the first inspection and on the analysis procedure recommended, 22 of the 60 ponds were described as being "in balance." Later judgment of these ponds, as revealed by seining with a large seine and by age analyses made that year or in following years, resulted in a list of 27 ponds in which the bass and bluegill populations were adequate and appeared capable of producing an annual harvestable crop of fish. Table 1 shows that the two methods resulted in different classifications for 13 ponds. Four of these ponds winterkilled after the minnow-seine analysis had found them in balance; the tabulated listings are for different years and are therefore not comparable.

As might have been expected, the more detailed and time-consuming method of population analysis made apparent some situations that were not revealed by the minnow-seine inspection. In four ponds (Nos. 12, 14, 25, and 51), young-of-year bass were not located by minnow seine but were located later that year by the larger seine or by age analysis of scales of fish captured. In four other ponds (Nos. 18, 33, 42, and 60), the bass did not reproduce during the year of inspection but did so in subsequent years. In Pond No. 43, the minnow seine did not reveal a heavy population of bullheads and slow-growing bass that subsequently came into population balance.

Other errors in the minnow-seine technique were revealed by later inspections of the ponds. Bluegill sometimes hatched late in the season and were found by

[1/] Moorman, R. B. Fish populations in some Iowa farm ponds in relation to past history and management. Iowa State College, doctoral thesis, 150 pp. 1953.

From Project 37 of the Iowa Cooperative Fisheries Research Unit, sponsored by the Iowa State Conservation Commission and the Industrial Science Research Institute of Iowa State College, with the cooperation of the U. S. Fish and Wildlife Service.

TABLE 1.--Comparison of results of Swingle method and population-study method of determining fish population condition in Marion County farm ponds

Ponds in balance, as shown by Swingle method and by population study	1, 2, 4, 5, 6, 8, 17, 22, 26, 27, 34, 38, 44, 45, 52, 54, 57, 58.
Ponds unbalanced, as shown by both methods	3, 7, 10, 11, 13, 15, 16, 19, 20, 21, 23, 24, 29, 31, 32, 35, 36, 37, 39, 40, 41, 46, 47, 48, 49, 53, 55, 56, 59.
Ponds in balance according to Swingle method, but unbalanced according to population study	9*, 27*, 30*, 50*
Ponds unbalanced according to Swingle method, but in balance according to population study	12, 14, 18, 25, 33, 42, 43, 51, 60

*One year between Swingle method study and population study, with a winterkill intervening.

inspections during August in ponds where the fish had not been in evidence earlier. Sometimes the minnow seine gave an erroneous picture of the species in the pond, particularly where the farmer had stocked a variety of species from creeks or elsewhere. Bullheads seemed to escape the small seine often, and heavy populations seemed not to be detected. In some ponds, particularly where suspended clay or other factors slowed growth of bass, there was no reproduction of bass in the second spring after stocking--but there was the next year. In general, it may be said that the minnow seine gave a fairly reliable representation of the population balance in most ponds.

Supplemental Stocking

Prior to the present study, technicians of the Marion County Soil Conservation District had attempted to correct currently unbalanced populations by a second stocking of bass or bluegill or both. In the present study, further attempts of this nature were made to bring ponds back into effective production. Fingerling bass and bluegill were moved from nearby ponds where reproduction was known to be high, and rates of stocking were usually somewhat higher than an original stocking. Sometimes yearling bass or adult bluegill were used rather than fingerlings (Ponds No. 3, 27, and 30). As shown by table 2, most of these attempts failed, probably for the same reasons that the first stockings failed in those ponds. Attempts to restock are not likely to succeed in ponds that tend to be at low level during the winter or that have a history of winterkill.

Thinning Population With Seine

There was one attempt to control a fish population by seining the pond and removing fish. When Pond No. 6 was inspected early in the summer of 1950, there appeared to be large numbers of adult white crappies and very large numbers of young-of-year crappies, plus good reproduction of bass and some reproduction of bullheads. Because it seemed likely that the crappies would soon dominate the pond, an effort was made to remove as many of the crappies as possible. All the larger crappies that could be taken economically with a 60-foot seine were removed, as were large numbers of the young-of-year crappies. The population during this seining was estimated to include 124 large crappies, and 105 were removed. Study of scales from these crappies and from a series of 45 crappies taken the following year showed that the year classes so prominent in 1950 had grown from a mean length of 7.5

TABLE 2.--Results of supplemental stocking in unbalanced farm ponds, 1946-51

Year of supplemental stocking	Pond numbers	Species stocked	Results of stocking
1946	14	Bass----------	Success.
1946	16, 33	Bass and bluegill	Failure in No. 16; success in No. 33.
1947	20, 49	Bass----------	Success in No. 20; failure in No. 49.
1948	7, 32, 46	Bass----------	Failure in all ponds.
1948	16, 24, 42	Bass and bluegill	Failure in Nos. 16 and 24; success in No. 42
1949	19, 35, 37, 40, 59	Bass----------	Failure in Nos. 19, 35, 37, 40; success in No. 59.
1949	16	Bluegill--------	Failure.
1950	24, 30, 49	Bass----------	Failure in No. 24; success in Nos. 30 and 49.
1950	16	Bass and bluegill	Failure.
1951	16	Bass and bluegill	In balance, 1953.

inches to a mean length of 10.8 inches during the year. In the same period the 1950 class had grown to a length of 6.7 inches.

Rotenone Treatment and Restocking

Eight of the ponds with undesirable fish populations were treated with rotenone. Five of these were successfully restocked and produced balanced bass-bluegill populations. In two of these ponds a few of the bullheads survived the rotenone treatment but did not interfere with the restocking. Failure in two ponds was due to winterkill the first winter after restocking. The cause of failure in the last pond was not established, but it was known that some bullheads had survived the rotenone treatment in this pond.

Acknowledgments

The authors are grateful to the farmers who permitted this work in their ponds and to the technical personnel of the Marion County Soil Conservation District. Thanks are due especially to H. J. Chandler of the Soil Conservation Service, whose enthusiastic cooperation and aid in the field made the work so enjoyable. Thanks are also extended to C. E. Ruhr, Paul Osborn, and John Lawrence for their aid in the field.

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In future, fish tallies may be made by a transistorized electronic counter. Fish pass through two plastic "tunnels" in the bottom of the uppermost pool of a fishway. In each tunnel, two distinct electrical fields of low voltage are created electronically. As fish flesh is a better conductor of electricity than water, movement of a fish through a tunnel causes an increased flow of electricity. This increased flow trips a series of electronic relays, which actuate a "logic device" that records passage of the fish--upstream or downstream, depending on the sequence in which the relays are tripped.

USE OF LATEX INJECTIONS TO MARK JUVENILE STEELHEAD

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A STUDY OF THE DOWNSTREAM MIGRATION OF JUVENILE STEELHEAD TROUT (Salmo gairdneri) has been part of a long-range life history investigation conducted by the Oregon Cooperative Wildlife Research Unit. A portion of the study required that the young fish be trapped and marked at successive locations on the Alsea River, which flows through Benton County and Lincoln County in Oregon.

During the preliminary phases of the inquiry, an attempt was made to develop a satisfactory mark for the juvenile migrants. Tagging and dye injections were tried and discarded as unsatisfactory. The removal of fins offered an insufficient number of the combinations necessary to designate trap locations and marking dates.

Tattoos have been used successfully in Washington by Dunstan and Bostick (1956) and in Oregon by the Research Unit.[1/] However, the marks produced by tattoo machines as presently used are recognizable for a maximum period of 5 months. In the hope of developing a more permanent mark, the Unit has conducted preliminary experiments with latex injections.

Colored liquid latex was used by Davis (1955) for marking green sunfish (Lepomis cyanellus) in Indiana. Fish were marked by inserting a hypodermic needle beneath a scale and immediately under the skin on the side of the body. As the needle was withdrawn, a small amount of latex was released and the scale was lowered to seal the opening. The green sunfish retained the latex marks for at least 6 months (the length of the observation period).

In experiments with young steelhead, a B-D Champion veterinary syringe (10 cubic centimeters) and a No. 21 needle were used. This syringe had rubber gaskets which kept the glass barrel from clogging with latex. Tuberculin or veterinary syringes with glass or metal gaskets clogged rapidly and thus became useless. Red, yellow, and blue latex mixtures were used.

As injections of latex in dark-skinned areas did not provide a conspicuous mark, the white ventral surfaces of the fish were selected for this purpose. The most satisfactory mark was produced by inserting the needle into the anus of the fish and forcing the point through the intestinal wall and along the body toward the ventral fins (figure 1). The needle was forced forward and outward until the point was plainly visible beneath the skin. Another point of easy entry lay between the ventral fins. Latex was released to form a small irregular patch (figure 2) or released during withdrawal of the needle to form a thin line of color.

No external wound resulted from the anal injection, and no apparent injury was suffered by fish marked in this manner. As part of an experimental release of marked hatchery steelhead, about 600 fish were given injections at the Oregon Game Commission's Alsea trout hatchery.

[1/] Chapman, D. W. An improved portable tattooing device. Unpublished. 1956.

The Oregon Cooperative Wildlife Research Unit is sponsored by the Oregon State Game Commission, Oregon State College, Wildlife Management Institute, and the U. S. Fish and Wildlife Service, cooperating.

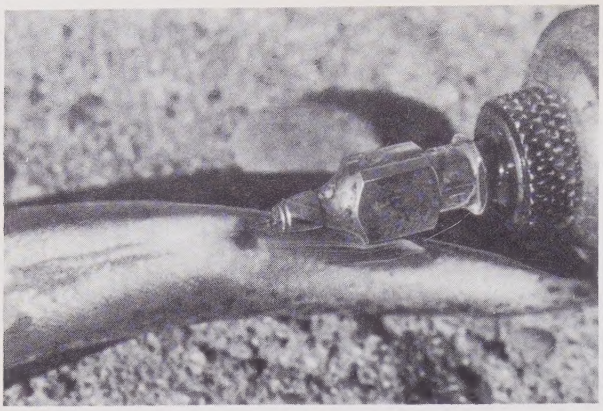

FIGURE 1.--Anal-injection method.
(Photographs courtesy of the author)

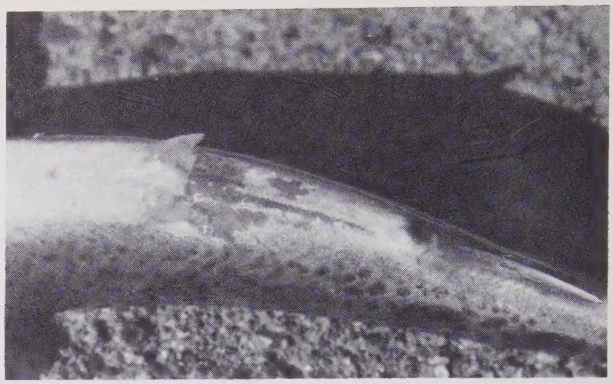

FIGURE 2.--Irregular patch of blue latex produced by anal-injection method.

These marked individuals were released in company with 7,500 tattooed fish. When taken in downstream traps on tributaries of the Alsea River, the fish that had received injections of latex appeared in the ratio in which they had been planted, indicating no differential mortality between latex-injected and tattooed steelhead. The marks were unchanged in intensity 8 weeks after the fish had been planted.

Fish that were given injections of latex on March 19, 1956, and were observed for 10 weeks had excellent marks at the end of the period.

When used by a practiced operator, the anal-injection method is almost as rapid as tattooing or fin-clipping. A variety of marking combinations may be developed by using several injection locations and latex colors. The simultaneous use of fin clips will provide still further marking combinations.

It seems likely that latex injections may be useful for marking other salmonoid fishes. As experiments to date have been short-term, plans have been made to conduct a long-term marking program on future rainbow brood stock to determine the permanence of the injections.

Acknowledgments

Thanks are due to H. R. Newcomb of the Oregon State Game Commission for his advice and encouragement. Personnel at the Game Commission's Alsea trout hatchery were most cooperative during the experiments.

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Species more commonly found in salt water--such as sharks, sawfish, and tarpon--may be taken in the fresh-water Lake Nicaragua, which was formed by a volcanic upheaval that dammed up a gulf of the Pacific Ocean. One of these sharks now acclimated to fresh water is Eulamia nicaraguensis, which reaches a weight of 200 pounds and can be found nowhere else.

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